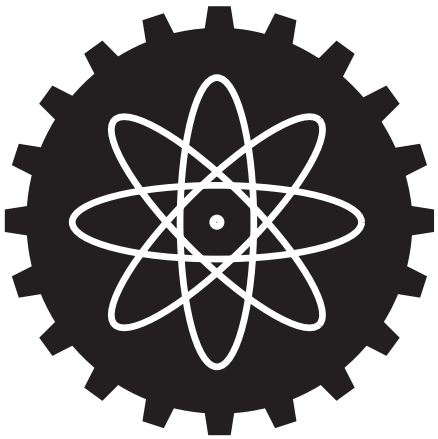
MISSOURI'S

Framework for Curriculum Development in

Science

K-12



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(SHOW-ME STANDARDS, SCIENCE 7)

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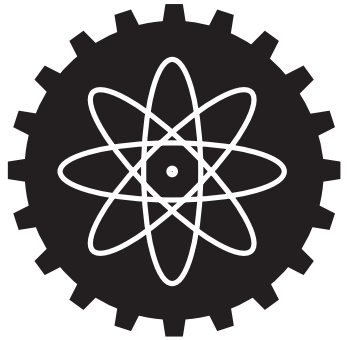


K-12 Content Overview:

Scientific inquiry refers to the skills, habits of mind, and attitudes that promote lifelong scientific learning and the ability to apply scientific processes in all facets of life. Traditional approaches to teaching students scientific inquiry often do not give students an accurate perception of the true nature of the processes involved. The result is that many people have the impression that science is nothing more than "doing experiments," and following a rigid sequence of steps referred to as "the scientific method." In reality, the process is far from rigid. More imagination and inventiveness are involved in scientific inquiry than many people realize.

The best way for students to appreciate the true nature of scientific inquiry is for them to participate in scientific investigations based on real-life questions that progressively approximate good science. This approach, however, will require major changes in typical school laboratory activities. Traditional laboratory activities are very unlike real science. They are often teacher-initiated, with the teacher not only specifying the question to be investigated, but also the experimental design, the data to be collected, and ways of organizing and interpreting the data. If students are to understand the process of science, they must make these decisions themselves. Time must be made for revision and repetition of experiments, for presentations of results to other investigators, and even for response to criticism.

Science requires the use of mathematical skills and formulas. Mathematics and science programs should be coordinated so each enhances the learning of the other. By using data from actual science investigations, students will gain experience in dealing with the inconsistencies and errors that occur. Scientific explanations are often clarified through accurate measurements. The metric system should be used consistently throughout the K-12 science experience with emphasis on using the metric system and not the conversion between the metric and other systems.

In addition to in-class laboratory activities that approximate good science, it is important to introduce student investigations. These investigations should become more sophisticated so that before graduating from high school, students should conduct at least one major investigation. Such investigations, whether individual or group, might take weeks or months to conduct, and may take place in or out of school.

I. Scientific Inquiry: A. Processes of Scientific Inquiry

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Tools, especially measuring, magnifying, and photographic ones, can give more information than by observing only using the senses.	a. use magnifiers and accurate simple metric measuring tools to observe and measure things in new situations and tasks (1.4; 1.6)	• Select a square plot of grass and make observations with magnifiers and metric rulers.
2. Sometimes two people can observe the same object or event and describe it differently.	a. carefully distinguish actual observations from ideas and speculations about what was observed; use information-processing skills to develop and clarify ideas and perspectives (1.5; 1.7)	• Use a periscope and develop an explanation of how it works. Work in groups to compare explanation and develop new understanding based on the explanations of the group.
3. Words, pictures, numbers, models, and sounds can be used to describe objects and events.	a. create communications that describe and compare things in terms of number, shape, texture, size, odor, sound, mass, color, and motion (2.1; 2.4; 2.7)	• Given a group of vegetables, seashells, leaves, etc., describe to another person a single item so that the person can pick it out from the group.
4. Using tools, following directions, and asking for suggestions are helpful in building something or getting something to work better.	a. use simple tools, follow directions, and/or ask for suggestions to make things that can actually be used to perform a task or solve a problem (1.5; 1.10; 3.2; 3.3)	• Use simple tools, follow directions, or ask for help in designing a paper boat that will hold 10 pennies and float across a pan of water.
5. Objects and events are often observed and described quantitatively.	a. use whole numbers and simple fractions to measure and describe things (1.8)	• Use simple measuring tools to measure an object that is usually described qualitatively and describe it using numbers.

I. Scientific Inquiry: A. Processes of Scientific Inquiry

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
6. The accuracy of measurements is very important as inaccuracy often produces questionable results.	a. judge whether measurements and computations of quantities are reasonable (1.7) b. compare measurements and computations to typical values with which students have had prior experience (1.10)	• Given a set of data, such as length, area, volume, mass, or time, identify values that are questionable (e.g., values that are much larger or smaller than the others). • Identify the appropriate units of measurements for common objects (e.g., amount of water in a cup, a bucket, or a swimming pool).
7. Additional, more careful observations resolve different explanations for the same event.	a. use simple equipment to observe more detail, measure more accurately, and obtain more information about the environment in order to develop more accurate explanations (1.4; 1.6)	• Participate in a simulated mystery in which incriminating "evidence" can be accurately determined only with the use of a microscope or hard lens.
8. Graphs, charts, maps, equations, and oral and written reports can be used to share the results of a scientific investigation and facilitate its discussion.	a. use a variety of methods, forms, and technologies to organize data into forms that are understandable (1.4; 1.8; 2.1; 2.2; 2.4; 2.7)	• Measure the growth and development of organisms, such as bean plants or mealworms, and communicate observations using graphs, charts, and symbols.
9. Problems can often be solved by physically altering specific components of a mechanical or biological system and observing the consequences.	a. select and apply appropriate technology and common materials for construction and repair of simple things and make safe electrical connections with various electrical devices for the purpose of solving a problem or performing a task (1.10; 2.2; 2.3; 3.5; 3.7; 3.8)	• Construct a "doorbell" for people with hearing impairment using wires, batteries, bulbs, etc.

I. Scientific Inquiry B. Investigations

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The breadth and style of investigations depend on the questions asked.	a. create and refine ideas and questions about the world by asking for information, making careful observations, and trying things out (1.1; 1.2; 1.6; 1.7)	• Observe a discrepant event, such as two balls of similar mass and size that do not bounce the same height, and formulate questions that might lead to an explanation.
	b. plan and conduct a simple investigation that includes fomulating a question, gathering data, and constructing a reasonable explanation.	• Predict what colors are present in the ink of different colored markers. Conduct an investigation and communicate an explanation.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
2. Most experiments involve changing something and then repeatedly comparing it to something similar that has not been changed.	a. plan and conduct a simple experiment that is repeated and properly controlled; then discuss and respond thoughtfully to a variety of conclusions and determine whether the claims are logical arguments based on results of the experiment (1.5; 1.7; 2.3; 3.4; 3.6; 3.7)	• Design two paper airplanes, identical except for one attribute, measure and compare the distance thrown. Discuss whether this is a fair test of how far the planes fly or of which plane is better.

I. Scientific Inquiry A. Processes of Scientific Inquiry

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Various statistical procedures are used to determine characteristics of sets of data as well as to determine the validity of experimental results.	a. apply mathematical procedures to investigations and data sets in order to determine patterns, relationships, and predictions (1.6)	• Use computer software to analyze data from a class experiment using various statistical procedures.
	b. find the mean and median of sets of data, calculate percent and ratios, and determine the units in which the values should be expressed (1.8; 4.1)	• Analyze the running speed of dinosaurs by measuring the distance between footprints on a simulated set of fossil tracks, then calculate the average stride length and the ratio of stride length to leg lengths. Compare these ratios to those of living animals, such as humans.
2. The use of tools allows more sophisticated means of observation and data collection, analyzation, storage, and retrieval.	a. read analog and digital meters that measure length, volume, mass, time, and temperature; use microscopes, cameras, and tape recorders for capturing information; and use computers to locate, select, identify, collect, store, manipulate, and receive information (1.4; 1.8)	• Use an electronic temperature probe connected to a computer to accurately measure and graph temperature changes associated with a variety of insulating materials.
3. The comprehensiveness and sophistication of science are dependent on the ability to determine and use appropriate tools and technologies.	a. using appropriate technologies, inspect, disassemble, and reassemble simple mechanical devices; assess what the various parts are for and what the effect would be of removing or changing individual parts; predict the most likely sources of malfunctions; and select and apply appropriate strategies to correct or prevent such malfunctions (1.6; 3.1; 3.2; 3.3)	• After assessing the racing performance of a variety of toy cars, inspect those with poor performance. Predict the most likely sources of malfunctions and use appropriate strategies and tools (magnifiers, pliers, etc.) to correct the malfunctions.
4. Communication and the open sharing of information and knowledge are essential parts of scientific inquiry.	a. locate, read, listen to, and view various forms of information to interpret and evaluate; organize information in text, tables, and graphs; and use a variety of methods, forms, and technologies to describe the meaning and implications of the information (1.4; 1.5; 1.6; 1.7; 1.8; 2.1; 2.7)	• Organize a science lesson using verbal communication, visual display, and hands-on experiences. Present this lesson to younger students.

I. Scientific Inquiry B. Investigations

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. A valid experiment, or "fair test," involves the manipulation of only one variable, while all others are held constant. Experiments should be repeated many times before accepting the results as true.	a. design and conduct investigations that include an adequate number of repeated trials, unbiased sampling, accurate measurement and record-keeping, and a comparison to a control (1.3; 3.1; 3.2; 3.3; 3.4)	• Design and complete an independent science investigation that includes repeated trials and is properly controlled.
2. Critical analysis of procedures, data, evidence, and conclusions developed during an investigation can be used to judge the quality and validity of the work.	a. analyze and evaluate arguments based on very small sets of data, experiments with few repeated trials, biased samples, or samples for which there was no control sample (1.5; 1.7; 3.4; 3.7)	• Read and analyze selected articles from "supermarket tabloids," which commonly include questionable and highly exaggerated stories, and identify possible sources of error, bias, and incomplete information.

SCIENCE 5–8

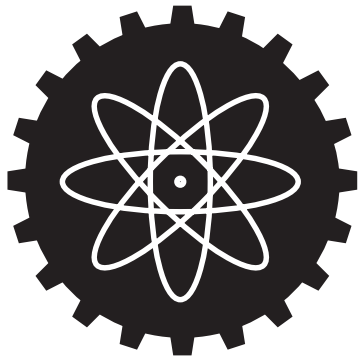
I. Scientific Inquiry A. Processes of Scientific Inquiry

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Investigations may involve mathematical procedures to interpret observations, make predictions, describe sets of data, and determine the validity and significance of experimental results.	a. analyze experimental data to determine patterns, relationships, perspectives, and credibility; use computer spreadsheets, graphing, and database programs to assist in quantitative analysis; and consider the possible effects of measurement errors on calculations (1.7; 1.8; 3.4; 3.6)	• Contact a professional scientist or statistician for advice about the design of an independent project and the statistical analysis of the data. Perform the recommended analysis using appropriate computer software.
2. Publication and presentation of scientific work with supporting evidence are required for critique, review, and validation by the scientific community. The presentation of such work adds to the body of scientific knowledge and serves as background for subsequent investigations in similar areas.	a. present arguments based on scientific investigations that include detailed procedures, graphs and tables, and conclusions; participate in follow-up discussions by responding to alternative positions (1.8; 2.1; 2.3; 2.4)	• Participate in a student seminar in which formal presentations of independent scientific investigations, defense of arguments and conclusions, and critical questions about the methods and conclusions are given.
3. Controlling all variables that might influence an experiment is important. Sometimes it is not possible, for practical or ethical reasons, to control some conditions, but a wide range of observations of natural occurrences can reveal patterns.	a. make systematic observations (nonexperimental) of natural objects or events to discern patterns, formulate explanations, support a thesis, or make predictions (1.1; 1.6; 1.8)	• Design a series of systematic observations that may reveal relationships or patterns of behaviors of an animal species under natural conditions.
4. Technological tools and techniques extend human capabilities to perform investigations in more detail and with greater accuracy and precision.	a. apply technological knowledge and skills to analyze and troubleshoot common mechanical and electrical systems, checking for possible causes of malfunction, and formulate and test logical and creative improvements that prevent future malfunctions. (1.6; 1.10; 3.2; 3.3; 3.6)	• Using basic electrical components and tools, such as soldering gun and pliers, construct a set of light (photocell) probes that can be connected to a computer. Use the light probes to make a photogate timer that will measure the speed of a moving object in a controlled experiment.

I. Scientific Inquiry B. Investigations

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The testing, revising, and occasional discarding of theories lead to increasingly better understanding, but not to absolute truth. New ideas, therefore, usually grow slowly from contributions by many investigators.	a. formulate questions for scientific investigations that indicate conceptual insights and a depth of understanding of the historical development of the idea or issue to be investigated (1.1; 1.9; 3.1; 3.4)	• After conducting a literature search on a topic, contact an expert in the field of interest by e-mail, pose questions for the expert about the historical development of the key ideas involved. Based on collected information, formulate a question for scientific research that indicates an understanding of past research and future directions.
2. Scientists attempt to improve objectivity of data observation and the academic integrity of their research by working in teams and seeking out possible sources of bias.	a. recognize and practice academic integrity while conducting investigations and developing solutions, seeking out sources of personal bias in the design of investigations (3.4; 4.4)	• Design an investigation that involves observation of the behaviors of vertebrate animals. Develop a list of guidelines to avoid biased descriptions of behavior, recognizing that animal behaviors are often mistakenly interpreted in human terms. Submit procedures and collected data to other students for confirmation of objectivity.
3. The testing of a hypothesis requires a structured and rigorous investigative process.	a. design and conduct a full scientific investigation including a comprehensive review of related literature: experimental design that is thoughtful and well-controlled, with adequate repeated trials; accurate measurement of data; some form of statistical treatment and display of data; thoughtful interpretation of data; and communication and defense of logical arguments supported by the finding (1.1; 1.2; 1.3; 1.8; 2.1; 2.2; 3.1; 3.2; 3.3; 3.4; 3.5; 4.1; 4.4)	• Design and conduct an independent science project following all of the guidelines of a nationally recognized science fair. Submit the project for competition in the science fair.

II. SCIENTIFIC RELEVANCE
(SHOW-ME STANDARDS, SCIENCE 8)



A. The Nature of Technology
B. Historical Perspective
C. Science as a Human Endeavor

K-12 Content Overview:

As long as there have been people, there has been technology. Indeed, the techniques of shaping tools are taken as the chief evidence of the beginning of human culture. On the whole, technology has been a powerful force in the development of civilization, all the more so as its link with science has been forged. Science and technology—like language, ritual, values, commerce, and the arts—are intrinsic parts of a cultural system that both shape and reflect the system's values. Consider, for example, how new ideas are limited by the context in which they are conceived. These ideas are often rejected by the scientific establishment; sometimes spring from unexpected findings, and usually grow slowly through contributions from many different investigators. Historical episodes such as Galileo's efforts to change perceptions of Earth's place in the universe, Newton's demonstration that the same laws of motion apply in the heavens and on Earth, Lyell's careful documentation of the age of the Earth, and Pasteur's identification of infectious disease with microscopic organisms are all concrete examples of how scientific theory and technology interact with social and political realities within a specific period of time. These examples also illustrate the power of individuals to conceptualize and change our understanding of the world around us.

Even in today's world, technology is a complex social enterprise that includes not only research, design, and crafts but also finance, manufacturing, management, labor, marketing, and maintenance. In the broadest sense, technology extends our abilities to change the world: to cut, shape, or put together materials; to move things from one place to another; to reach farther with our hands, voices, and senses. We use technology to try to change the world to suit us better. The results of changing the world are often complicated and unpredictable. They can include unexpected benefits, unexpected costs, and unexpected risks. Anticipating the effects of technology is, therefore, as important as advancing its capabilities.

(Benchmarks for Science Literacy, AAAS 1993)

II. Scientific Relevance A. The Nature of Technology

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Tools that have been invented affect all areas of life.	a. develop realistic strategies and use various objects to solve simple environmental or social problems encountered in school or community (3.1; 3.2; 3.3)	• After saving milk jugs for a period of time, discuss the benefits of these devices and the problems that have resulted due to difficulties with disposal. Develop reasonable strategies to bundle them and transport them to a recycling center.
2. When people want to build something or try something new, they should try to figure out ahead of time how this might affect all living things and environments.	a. predict, analyze, and evaluate the potential effects of technological solutions to simple problems on other people or the environment, considering such issues as costs, benefits, and consequences (3.6; 3.7; 3.8)	• Considering a specific technological solution to a problem, such as covering the playground with a rubber surface to prevent injuries, generate lists of possible positive and negative consequences of this solution.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
3. Technology extends the ability of people to change the way things work.	a. develop several alternative strategies to solve existing and potential environmental or technological problems, analyze and evaluate the alternatives by comparing strengths (such as safety or ease of use) and weaknesses (such as cost or appearance), and determine the best solution (3.6; 3.7; 3.8)	• Working in groups, design a new communication system for the school to replace the existing intercom system. Compare the alternative solutions from each group and generate a list of strengths and weaknesses of each one.
4. Technological solutions to problems often have drawbacks as well as benefits.	a. predict possible negative consequences, to people, other organisms, or the environment, of technological solutions to specific problems (3.6; 3.7; 3.8; 4.7)	• Considering a specific technological solution to a problem, such as controlling insects in farm crops, list possible alternative solutions and drawbacks of each.

II. Scientific Relevance B. Historical Perspective

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Throughout human history, technological innovations have played an important role in improving the quality of life.	a. investigate, discuss, and raise questions about the past, and possible future, contributions of science and technology to individuals and society (1.2; 1.9; 2.3; 2.4; 3.4; 3.6)	• Examine a variety of old technological devices and speculate what the object was used for, how it helped people, and what problems it might have caused.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
2. Advances in science and technology are occurring at a faster rate today than in the past.	a. identify some reasons/causes for recent increases in technological advances	• List some of the major inventions within a 20-year period of the 19th century and compare this to the major technological advances of the past 20 years.

II. Scientific Relevance C. Science as a Human Endeavor

By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Science is a way to solve problems; everybody can do scientific activities, discover some things about nature, and invent things and ideas.	a. work with a group to solve a problem, giving due credit to the ideas and contributions of each group member (2.3; 3.6; 4.4; 4.6)	• Read a variety of short stories and discuss science as a human endeavor in which men and women from different cultures have participated.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
2. Science requires many different kinds of activities, involving men and women of all ages and backgrounds.	a. recognize the various ways in which science and technology impact on all career and occupational areas (4.3; 4.8)	• Use a variety of resources (e.g., books, films, on-line resources guest scientists, field trips to describe the many different kinds of science-based occupations and the diversity of individuals in the scientific community.

II. Scientific Relevance A. The Nature of Technology

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The issues related to science, technology, and society are often complex and involve risk/benefit trade-offs.	a. analyze, evaluate, and communicate both benefits and possible risks to health, society, and the environment associated with investigations and technological advances reported in the media (1.1; 1.2; 1.7; 1.9; 2.1; 2.2; 2.3; 3.1; 3.5; 3.6; 3.8; 4.1; 4.3; 4.4; 4.6)	• Explore what conditions were like under different technological circumstances in the past (e.g., inadequate control of sewage, limited means of preserving food, inefficient methods of heating and lighting houses). Identify the products, processes or technologies that have been developed to improve these situations and consider whether the short-term and long-term benefits outweigh the short-term and long-term risks.
2. Breakthroughs in science often lead to advances in technology, and improved technological equipment leads to more accurate data collection in scientific inquiry.	a. identify and analyze ways in which advances in science and technology have affected each other and society (1.1; 1.2; 1.6; 1.7; 1.9; 3.8)	• Research and identify the advances in surgical procedures that have resulted from new technologies (such as laser surgery, lapiscopic surgery, CAT scans, MRIs).

II. Scientific Relevance B. Historical Perspective

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Important contributions in science have been made by many different people, in different cultures, and at different times. Their places of work include offices, classrooms, laboratories, farms, factories, and natural field settings everywhere.	a. identify the background qualifications and training that are needed in order to have careers related to science and technology (4.8)	• Research the life, work, and contributions of a contemporary or historical scientist. Compare the background qualities and other factors that influenced the work and training of the scientist.
2. Some people (e.g., women and minorities) have sometimes been discouraged or denied the opportunity of participating in science because of education or employment prejudices and restrictions.	a. describe some of the funding sources that can be used to finance education and training in science and technology (1.2; 1.4; 1.7)	• Explore the strategies that have been used in Missouri to increase the representation of women and minorities in the scientific workforce.

II. Scientific Relevance C. Science as a Human Endeavor

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Scientific ethics require that scientists must not knowingly subject coworkers, students, human research subjects, the neighborhood, or the community to health or property risks without their knowledge and consent.	a. evaluate possible risks to classmates, research subjects, or the community associated with their own independent investigations (1.2; 1.4; 1.7; 1.10; 4.3; 4.4; 4.7)	• For your own investigations, submit written justification for the investigation, forms for permission to use intended sites or property, and consent forms from human participants. Predict both positive and negative outcomes possible in any experiment.
2. Social, cultural, environmental, and economic factors all influence which science and technology will be undertaken and used. Society and the environment are directly influenced by the discoveries of science and products of technology.	a. analyze and evaluate the economic, political, social, ethical, and aesthetic constraints that might affect progress with specific scientific technological endeavors (3.1; 3.4; 3.5; 3.6; 3.8; 4.1)	• Work in teams to investigate current political, budget-related events and their impact on funding of scientific endeavors.

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Social and economic forces, such as personal values, consumer acceptance, patent laws, the federal budget, current regulations, media attention, and economic competition strongly influence the direction of progress of science and technology. Progress in science and technology, on the other hand, often result in many ethical, legal, and public policy issues.	a. discuss the scientific, technological , and political aspects of major challenges to society. Describe how each of these aspects influences public policy formulation in dealing with the challenges (2.3; 2.4; 4.1; 4.3; 4.7)	• Form a mock presidential cabinet and prepare arguments to be presented to the president expressing the opinion of each cabinet position on the issue of funding for the National Science Foundation in the next annual budget.
2. Human beings have a huge impact on other species, their environments, and technology. These impacts include reducing the amount of habitat available, interfering with food sources, changing the temperature and chemical composition of their habitats, introducing foreign species, and altering organisms directly through selective breeding and genetic engineering.	a. analyze and evaluate how specific technological solutions may impact the environment in areas such as habitat loss, disruption of the food web, and temperature and chemical changes (1.1; 1.2; 1.6; 1.7; 3.1; 4.1)	• Working in groups, explore examples of the environmental impact of energy sources used extensively in the past and the societal and technological changes which brought about a change in their use. Using this as background, propose ways to balance current energy needs with reduced environmental impact.

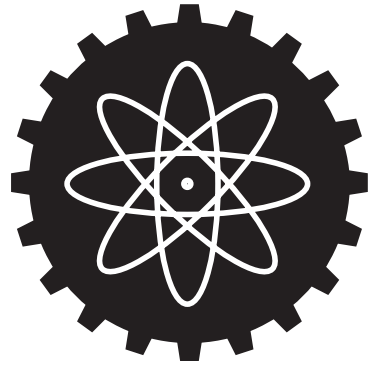
II. Scientific Relevance B. Historical Perspective

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Scientific theories are developed based on the body of knowledge that exists at any particular time. The driving force to find what is really true motivates scientists to test the validity of these theories and as a result the mysteries of nature are continuously probed and explained as new theories are created and old theories discarded.	a. identify and analyze theories that are currently being questioned, and compare them to new theories that have emerged to challenge the older ones (1.2; 1.5; 1.6; 1.7; 1.9; 2.4; 3.7; 4.1)	• Identify a scientific theory that is currently being modified or debated based upon new data being gathered by the scientific community (e.g., structure of the atom, origin and evolution of the universe, formation of Earth's geological features). Discuss the interplay that exists between theory and the new information.
2. The history of scientific thought spanned many cultures and centuries. The early Egyptian, Greek, Chinese, Hindu, and Arabic cultures are responsible for many scientific and mathematical ideas and technological inventions. Modern science is based on traditions of thought that came together in Europe about 500 years ago. All cultures now contribute to that tradition.	a. identify and analyze various scientific concepts, inventions, and technological innovations that have been developed by different cultures from around the world; discuss the influence of prevailing contemporary thought on the acceptance of these concepts, inventions, and innovations by other scientists and society (1.2; 1.5, 1.6; 1.7; 1.8; 1.9; 2.1; 2.2; 2.3; 2.4; 4.1)	• Develop a timeline of the major scientific and mathematical concepts and/or technological inventions from the early Egyptian, Greek, Chinese, Hindu, and Arabic cultures.

II. Scientific Relevance C. Science as a Human Endeavor

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Scientists make mistakes like all people. Deliberate deceit, however, is rare and is likely to be exposed eventually by the scientific enterprise itself.	a. identify, discuss, and respond thoughtfully to information from credible sources, such as scientists making claims in their areas of expertise, and from sources of questionable credibility, such as people whose own personal, institutional, or community interests are at stake (1.5; 1.7; 1.8; 2.1; 2.2; 2.3)	• Read a collection of articles, including peer-reviewed articles from science journals, newspaper articles, and "supermarket tabloid" articles, about a science-related issue such as the New Madrid fault. Analyze the credibility and documentation of each article.
2. Research funding comes from various federal government agencies, industry, and private foundations. Research grant proposals are written to promote research that is relevant, well-designed, cost efficient, and well-supported by previous research.	a. analyze a scientific research grant proposal and defend or dispute, in an organized and convincing way, sections that promote the proposed research (1.2, 1.5; 1.7; 1.8; 2.1; 2.2; 2.4; 4.1)	• Prepare a mock grant proposal, justifying and promoting the proposed research, for funding from a government agency or private sector.

III. MATTER AND ENERGY
(SHOW-ME STANDARDS, SCIENCE 1)



A. Properties, Characteristics and Structure of Matter
B. Characteristics, Forms and Sources of Energy
C. Interactions of Matter and Energy

K-12 Content Overview:

The physical universe is composed of matter. Students must develop a basic understanding of nature, structure, and properties of matter. They should also experience and learn how matter is changed and how the uses of matter are related to its properties. Every physical object in the universe consists of relatively few types of matter called elements. Elements consist of unique kinds of atoms that combine in different ways to form substances. The arrangement of the outermost electrons in an atom determines how atoms bond to form materials. Each of the elements consists of only a few naturally occurring isotopes. Every substance can exist in a variety of different states, depending on temperature and pressure.

The flow or energy between objects, between different parts of the biosphere and from one part of the universe to another drives the continual process of change occurring throughout all physical systems (biological, chemical, geological). Society needs abundant energy sources to improve its economic productivity and the quality of life. Students need to understand the fundamentals of energy and the natural laws that govern force and motion. Energy occurs in several forms: chemical, electrical, electromagnetic, mechanical, nuclear, and thermal, which are interchangable. Most of the processes in the universe, from exploding stars to the operation of machines, involve the transformation of energy from one form to another. This transformation usually produces some heat energy that is lost by radiation or conduction. Whenever the amount of energy in one place or form diminishes, the amount in another place or form increases by an equivalent amount. Energy as well as matter occurs in discrete (quantum) units.

III. Matter and Energy A. Properties, Characteristics and Structures of Matter

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Observable properties are used to identify objects.	a. identify physical properties of objects and sort according to specific properties (1.3; 1.8; 4.1)	• Sort common objects (buttons, rocks, blocks) using specific properties. Describe what properties were used.
	b. identify physical properties of objects that are detected using the senses (1.3; 2.4; 4.1)	• Use granular Jell-O and glue to make "scratch and sniff" stickers or pictures. • Use feely boxes to describe and predict the object they are holding without using their eyes. • Investigate colors by mixing new colors in a variety of mediums (e.g., food colors in frosting or water).
	c. demonstrate that magnification enhances the ability to observe the properties of small objects (1.4; 1.6; 2.1)	• Inspect several objects with and without a hand lens. Discuss and describe the increased level of detail that can be observed with magnification.
	d. describe a material as its form and size is changed (1.6; 2.2; 3.5)	• Observe and describe changes in a material (e.g., paper, a leaf) as it is cut into increasingly smaller pieces. Use a magnifying glass to compare characteristics of the smallest segments with the original.
2. Matter has physical properties that can change.	a. identify ways heat and light affect common objects (1.3; 3.5)	• Describe the physical changes that occur when newspaper is left in the sun, potato slices are left exposed to air, cereal left in a bowl of milk, etc.
	b. compare and contrast the physical properties of a solid and liquid of the same material (1.2; 1.4; 1.6; 2.3)	• Describe and compare the physical properties of water and ice.
3. Mixtures are composed of different kinds of matter, each with distinct properties.	a. separate, sort, or group the components of a mixture by their properties (1.3; 1.4; 1.6)	• Prepare a trail mix, or tossed salad. Discuss how the properties of the mixture are different from the properties of each component. Design a way for the mixture to be separated.

III. Matter and Energy A. Properties, Characteristics and Structures of Matter

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
4. Matter is anything that has mass and volume and is composed of smaller parts.	a. select and classify a variety of common materials and objects as being composed of one substance or more than one substance (1.2; 2.3; 3.5)	• Identify things that are combinations of substances (e.g., bricks, concrete, cakes, cookies).
	b. refine and adapt the parts of objects to create a new object (1.4; 1.6; 3.1; 4.6)	• Identify the parts used to make a lamp, coffee pot, sofa, etc.
	c. demonstrate the mass of an object equals the sum of the masses of its parts (1.2; 2.4)	• Construct an object out of Lego blocks, take it apart, and rearrange the parts to make a new object. • Mass an object made of Tinker Toys, Lego, Lincoln Logs, etc. Take the object apart and total the mass of each component.
5. Substances can occur either in pure form or as a mixture.	a. predict the properties of a mixture given the concentration of ingredients (1.6; 2.3; 3.5)	• Prepare different concentrations of Kool-Aid, Jell-O, etc. Observe and compare differences in the properties of these mixtures to the concentrations used (color, taste, etc.).
	b. identify the factors that determine the choice of materials for a particular purpose (1.6; 2.3; 3.2; 3.3; 3.5)	• Investigate the properties of devices that make them useful for a given purpose in the real world. Use this knowledge to design a common object or to solve a problem (types of clothing, types of furniture, etc.)
6. Physical properties of matter can change.	a. use magnifiers, measuring tools, and other technology to identify the properties of matter or objects (1.2; 1.3; 1.7)	• Inspect and describe the physical characteristics of salt, flour, sugar, etc. Expand the description by using magnification.
	b. select and apply strategies to change matter by heating or cooling predict what changes will occur (1.3; 1.6; 2.4; 3.5)	• Investigate how much energy it takes to change water to ice or steam.

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
	c. observe and describe the effects of the environment on a variety of objects (dissolving, weathering, shrinking, melting, rusting) (1.6; 2.1)	• Observe the long-term effects of the environment on a block of salt, a patch of snow, an exposed piece of iron, etc., and describe the changes.

III. Matter and Energy B. Characteristics, Forms and Sources of Energy

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The sun is the primary source of light and heat for the Earth.	a. predict how sunlight will affect the temperature of air and water (1.2; 1.4, 1.6; 4.1)	• Record and compare the temperatures of air and water at various times during the day, on cloudy and on clear days.
2. Energy can be converted into different forms.	a. identify and describe the transformation of energy from one form to another (1.2; 1.4; 3.5; 4.1)	• Use a lamp to demonstrate how electricity is transformed to light and heat energy.
3. Sound is a form of energy that results from vibrations in matter. Sound has the qualities of loudness and pitch.	a apply knowledge of sound, learned from altering loudness and pitch (1.2; 1.3; 1.6)	• Identify sounds around the school and identify the source of the vibrations. • Design a phone system from string/cans or funnels/tubing. Explain why it works.
	b. change the pitch of a stringed instrument by changing the length of the strings and the loudness by the energy of the vibration (1.1; 1.2; 1.3; 1.6)	• Investigate the kinds of sounds produced from different lengths of string, different amounts of water in a bottle, or different types of bells and predict what sounds would be produced with additional variations.

III. Matter and Energy B. Characteristics, Forms and Sources of Energy

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
4. Some of the sun's light is transformed into heat when it hits objects.	a. predict the effect of sunlight on various objects, liquids, and solids (1.6; 2.3; 3.5)	• Measure/record how the sun's light is transformed into heat (e.g., asphalt road, concrete, dark clothing). Demonstrate ways this is useful (e.g., melt ice faster, run a solar calculator, make sun tea, warm a room).
5. Electricity can be converted into light, heat, sound, magnetism, or mechanical motion.	a. apply knowledge of simple circuits to create a new circuit that involves more components (1.10; 3.5; 4.1)	• Use a battery, wires, and a light (or a motor or buzzer) to demonstrate the requirements for a complete circuit. Observe the effect of interrupting the circuit.
6. Friction produces heat.	a. identify and consider a variety of methods that produce heat by friction (1.2; 1.3; 1.6; 3.5)	• Investigate how heat is produced by friction. Identify the source of friction and the amount of heat generated (rubbing hands together, rubbing pieces of metal together, shaking sand in a can, etc.).
7. Sound travels at different rates through different materials.	a. select and apply technology and other resources to show that sounds travels through some materials better than in others (1.4; 2.3; 3.5; 4.6)	• Use a tuning fork to show the vibrations produced on a rubber membrane, on metal, or on wood. • Use a tuning fork to show how sound travels through water. Relate this to animals who use sonar.
8. Light spreads from a source and travels in straight lines. Light can be transmitted, reflected, refracted, or absorbed by different materials.	a. predict which materials will reflect, which will absorb, and which transmit light (1.2; 1.6; 2.3; 3.1)	• Use glass, clear plastic, cloudy plastic, paper, etc. to determine which ones transmit light, partially transmits light, or casts shadows. • Observe the changes in shadows at different distances from a light source and different angles between the light source and objects. • Manipulate a reflected beam of light through a maze.
	b. use lenses or water to observe examples of the bending of light; use mirrors or a water surface to show how light is reflected (1.6; 3.5)	• Generalize where a light source is when shadows are shortest/longest, where a fish is when seen from shore, etc.

III. Matter and Energy C. Interactions of Matter and Energy

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Objects that give off light may also give off heat.	a. identify and consider a variety of light sources to determine which give off heat (1.1; 1.3; 1.6; 2.3; 3.5; 4.1)	• Compare the heat from several light sources (e.g., incandescent bulb, fluorescent bulb, sun, halogen bulb).
2. Heat causes materials to increase in temperature and feel warmer, or change state (gas, liquid, or solid).	a. select and apply strategies to show how heat causes materials to increase in temperature and makes it feel warmer (1.2; 1.3; 1.6; 2.3; 3.5; 4.1)	• Use a light bulb and a thermometer to compare how heat flows through different materials (e.g., aluminum, air, colored paper, cloth).
By the end of grade 4, all students should know	*By the end of grade 4, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
3. Warm objects lose heat to cooler ones until they reach the same temperature.	a. identify which materials will become warmer and which materials will become cooler when mixed (1.2; 1.6; 1.10)	• Explore how heat flows from warm objects to cooler ones, (ice cubes in water) to equalize the temperature.
4. Different types of matter conduct heat at different rates.	a. identify characteristics of conductive materials and of insulative materials (1.2; 1.6; 3.5)	• Investigate different materials used to make cups to determine which are good conductors of heat and which are good insulators.

III. Matter and Energy A. Properties, Characteristics and Structure of Matter

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. In a closed system, matter is conserved during any physical or chemical change.	a. use laboratory investigations to demonstrate the formation of new materials and demonstrate the conservation of matter (1.3; 1.6; 2.4)	• In laboratory investigations, demonstrate precipitation, gas evolution, electrolysis of water. Compare the mass of the substances before and after a chemical change.
2. Some physical properties depend on the amount of matter present while other properties do not.	a. identify those properties that are characteristic of a substance and those that depend on the amount of substance present (1.2; 1.6; 1.8; 2.3; 3.2; 3.3)	• Design and perform experiments that identify the melting point, density, mass, volume, etc. ,of water.
3. Almost all matter is derived from naturally occurring elements. Each element is made of atoms that bond together to form molecules.	a. investigate changes of state of water and use the particulate model to describe these changes (1.1; 1.2; 1.3; 1.6; 1.7; 3.2; 3.3)	• Construct models of water, sodium chloride, or hydrogen and discuss the relationship of the structures to the physical properties of the substance.
4. The arrangement, motion, and interaction of molecules determine the physical state for the matter.	a. investigate property changes as a result of changes in the physical state of a substance (1.1; 1.2; 1.3; 1.6; 1.7; 3.2; 3.3)	• Demonstrate the volume changes due to changes in the physical state of iodine, water, or dry ice.
	b. investigate how the rate of change of state is affected by the addition or removal of heat (1.1; 1.2; 1.3; 1.6; 1.7; 3.2; 3.3)	• Measure and compare the rate of melting of ice on different colored fabrics exposed to sunlight.
5. Compounds can be analyzed and separated by making use of their unique chemical and physical properties.	a. separate natural or synthetic substances into their component compounds (1.3; 1.4; 3.5; 4.6; 4.7)	• Determine the most appropriate methods to separate milk, blood, sea water, processed foods, paints, cosmetics, etc. into their component parts.
	b. investigate and report why certain components of mixtures are reported to the public and how they are used to monitor health problems and/or environmental pollutants (1.2; 1.3; 1.8; 2.1; 3.2; 3.3; 4.1)	• List the fat content in a variety of meats, canned vegetables, breads, snacks, etc., and identify the potential health problems/benefits associated with eating those foods.

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
6. Chemical changes occur at the atomic level to form new substances with different properties.	a. identify chemical changes in common objects as a result of interactions with heat, light, air (1.6; 1.1; 3.1; 3.5)	• Identify and describe the chemical changes in various materials by observing everyday events (nail left in water, cooking vegetables).
7. Solution properties depend on concentration and nature of the substances involved.	a. identify the components of a solution, demonstrating the use of ratios and percents in preparing different concentrations of the solution, and compare the properties of different concentrations of the solution (1.2; 1.6; 1.8; 3.1; 3.5)	• Mix four different concentrations of Jell-O solutions, reporting the ratios of the components, and compare the taste, viscosity, color, etc., of the four solutions.

III. Matter and Energy B. Characteristics, Forms and Sources of Energy

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Most processes involve energy transformation with the release of heat. However, the total amount of energy remains constant.	a. measure and quantitatively compare the heat changes involved in an energy transformation (1.2; 1.3; 1.6; 1.8; 2.4; 3.5)	• Measure and compare the temperature differences in incandescent and fluorescent light bulbs of various wattage when they are on.
2. The electromagnetic spectrum consists of energy bands of visible and nonvisible wavelengths. White light from the sun consists of a mixture of wavelengths and energies in the visible part of the electromagnetic spectrum.	a. identify the wavelengths and energies in the visible part of the electromagnetic spectrum (1.3; 1.6; 3.5) b. identify and discuss the use/misuse of the non-visible part of the electromagnetic spectrum (1.7; 1.10, 2.4; 3.8; 4.7)	• Use a prism or diffraction grating to separate white light. Explain the colors and their order in terms of their wavelengths and energies. • Identify and discuss the use/misuse of microwaves, UV light, and x-rays.
3. Electrical energy is transferred by the the movement of electrons driven by a voltage through a complete circuit and is extremely useful to humankind.	a. understand the advantages and disadvantages of series and parallel circuits (1.2; 1.3; 1.4; 1.6; 1.10; 3.7) b. compare various sources of energy for the generation of electric power (1.10; 2.4; 3.8; 4.7)	• Design and demonstrate simple series and parallel circuits. Discuss the advantages and applications of each. • Research and discuss the advantages and disadvantages of the use of coal, natural gas, wood, and oil in the generation of electricity.
4. Static electricity is potential energy stored in a collection of separated negative and positive charges.	a. predict specific conditions that will cause static electricity (1.2; 1.6; 2.4; 3.5) b. understand applications and hazards of static electricity (1.10; 2.4; 3.8; 4.7)	• Generate static electricity from various sources (e.g., rubbing fur on plastic rods, combing hair) and investigate conditions under which this happens. • Discuss the hazards of a build up of static electricity (around computers, lightning).
5. Chemical energy is stored in chemical bonds between atoms in the elements and compounds.	a. identify sources of chemical energy used in commercial and industrial activity and in life processes (1.7; 1.10; 2.4; 3.8; 4.7)	• Identify sources of chemical energy encountered every day (batteries, food) and discuss its importance to life and society.

III. Matter and Energy C. Interactions of Matter and Energy

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Energy is required to produce changes in matter and do to work.	a. design, conduct, and communicate about an investigation that shows the relationship between energy and changes in matter (1.3; 1.6; 2.1; 2.7; 3.8)	• Measure the amount of energy required to melt a known mass of ice and compare it to the energy needed to boil water.
2. Heat energy can be transferred by conduction, convection, or radiation.	a. discuss the roles of radiation, convection, and conduction in weather changes (1.2; 1.6, 2.3; 2.4; 3.5; 4.6)	• Use weather maps and reports over an extended period of time to show the effects of uneven heating and cooling of Earth's surface on weather.
3. The interaction between matter and energy can result in changes in electronic, atomic, and molecular motion.	a. explain how an energy source interacts with and causes changes in different materials (1.3; 2.1; 2.4; 3.5; 4.1)	• Use measurements to show how microwave heating affects various materials such as plastic, glass, or water. Explain the results in terms of changes in electronic, atomic, or molecular motions.
4. Different materials have different electrical resistance. Resistance converts electric energy into heat energy.	a. explain the characteristics of a substance that makes it a good conductor or insulator (1.3; 2.1; 2.4; 3.5; 4.1)	• Use various materials in a simple circuit to show the difference between conductors and insulators and compare the efficiency of electrical conductors.
5. Energy travels through matter as waves.	a. identify waves as mechanical or electromagnetic and identify common wave properties (1.2; 1.6; 1.7; 3.5)	• Classify waves as mechanical (sound, tidal, earthquake) or electromagnetic (radio, sunlight).
	b. discuss how waves interact with barriers and each other (1.6; 2.3; 3.5)	• Generate waves in a water tank to demonstrate common wave properties when they interact with barriers (such as sides of tank, rocks, slits in paraffin) and each other.

III. Matter and Energy A. Properties, Characterisitics and Structures of Matter

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The Periodic Table organizes the elements according to their physical properties and chemical reactivity.	a. demonstrate how the Periodic Table can be used to predict the properties of elements and determine trends in these properties as they relate to the physical world (1.6; 2.4; 4.1)	• Use any one family of elements on the Periodic Table to show what common reactions or properties exist in related compounds and what uncommon or unusual differences exist. • Use atomic mass data to determine a substance's molar mass, percent composition, etc. • Conduct appropriate investigations to verify various scientific laws (e.g., conservation of matter, definite composition, multiple proportions). • Investigate and report on the historical development of the modern Periodic Table.
2. Models can be used to represent elements, compounds, and ions.	a. describe the molecular, atomic, and ionic make-up of a variety of substances; use the appropriate formula to represent these substances explain how the arrangement and motion of molecules determine a variety of biological, chemical, and physical phenomena (1.6; 1.8; 2.2; 3.5) b. use bonding diagrams to show ionic and covalent bonding and to predict the outcome of a chemical reaction (1.5; 1.8; 2.2; 3.5)	• Construct models of carbon dioxide, nitrogen, butene, and butyne. Identify single, double, and triple bonds and draw the structural formula for each. • Construct models or draw structural formulas representing the substances found in household products. • Observe and record the patterns of some of the properties of benzoic acid, magnesium chloride, potassium iodide, etc., that distinguish ionic compounds from covalent compounds.
3. Solution properties depend upon the concentrations, properties, and interactions of the solutes and solvents.	a. analyze and discuss the types and concentration of solute or solvent that affect the rate of solubility, acidity, viscosity of the solution (1.3; 1.6; 1.8; 2.4; 3.2; 3.3; 4.1)	• Investigate and report on examples of how different types and concentrations of solutions are used (de-icing roads, windshields, aircraft). • Conduct appropriate investigations to verify the type of solution (acid, base, or neutral) and concentration of household products. • Investigate and report the environmental impact of various types and concentrations of solutions.

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
4. The particulate model describes the electrically neutral atom.	a. describe the components of the modern model of an atom and how they are related (1.4; 1.6; 2.4; 4.1)	• Research the development of the understanding of the atom from the early Greeks to modern scientists. Report the discoveries that influenced the development of models of the atom.

III. Matter and Energy B. Characteristics, Forms and Sources of Energy

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Chemical and nuclear reactions provide energy that sustains industrial, life, and social processes.	a. conduct an investigation on how energy has been obtained/used and the consequences of its use (1.1; 1.2; 1.3; 1.4; 1.6; 1.10; 3.8; 4.7; 1.9)	• Explore examples of the environmental impact of energy sources used extensively in the past such as peat, wood, or water and the societal and technological changes that brought about a change in their use. Using this as background, propose approaches to balance current energy needs with reduced environmental impact.
2. The amount and rate of energy change for any process can be quantified.	a. determine the amount of heat required to change the temperature or state of a substance (1.2; 1.3; 1.7, 2.7; 3.5)	• Measure the heat released when the chemical energy stored in fuels or foods is released upon combustion. Discuss and account for the energy balance in the process.
3. Energy can be transfered as waves. The frequency and wavelengths of the waves are affected by the relative motion of the source and receiver.	a. explain the Dopplar Effect and identify some of its applications (1.10; 2.4; 4.1)	• Demonstrate the Dopplar Effect by using a decibel meter to measure the apparent change in the sound of a train whistle as it passes. Research the application of the Dopplar Effect to the measurement of distances and relative movement of stars or weather systems.
4. Voltage and resistance affect the flow of electric current in a circuit.	a. design an electrical circuit (1.3; 2.3; 3.2; 3.3)	• Construct parallel or series circuits and apply Ohm's Law to evaluate the components of the circuits. • Research and report the appropriateness of the use of series or parallel circuits in the home and industry.

III. Matter and Energy C. Interactions of Matter and Energy

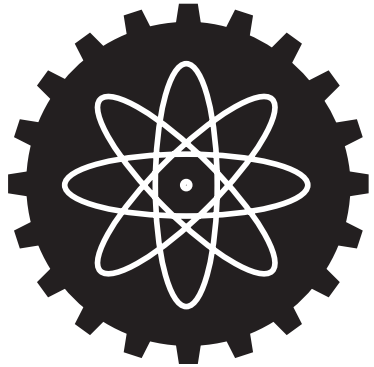
What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Chemical, physical, and nuclear changes involve energy transfers.	a. describe how energy is involved in chemical, physical, and nuclear changes (1.6; 1.8; 2.1; 2.4; 3.5)	• Determine the amount of heat required to change the temperature or state of water.
2. Heat flows from a body of a higher temperature to one of a lower one.	a. distinguish the direction of thermal energy in natural processes (1.3; 1.10; 3.5)	• Measure the heat transfer by conduction, convection, or radiation; discuss the advantages of each method and identify its use in the household.
	b. investigate the relationship between heat and work (1.3, 1.4, 1.8, 2.1, 2.4, 3.5, 4.1)	• Diagram and explain how the interior of a refrigerator is cooled.
3. Phase changes can occur due to a quantitative transfer of heat energy.	a. investigate phase changes that are induced by adding/subtracting heat energy and explain, using the particulate model, how the interaction of atoms or molecules during a change of state affects the properties of the substance (1.2; 1.3; 1.6; 2.1; 2.4; 3.5)	• Identify and measure the energy transfers occurring during the making and freezing of homemade ice cream. • Drop an ice cube in water. Monitor the temperature of the water every 10 seconds. Plot a "temperature vs. time" graph and compute the heat of fusion of water.
4. The interaction of energy and matter may result in the formation of heat or other energy forms.	a. describe the interaction of energy waves with the materials of man-made devices (1.3; 1.6; 1.10; 2.1; 2.4; 3.5; 4.1)	• Investigate the interaction of energy in electric heaters, solar cells, remote control units, etc. Discuss the efficiency of such devices.

III. Matter and Energy C. Interactions of Matter and Energy

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
5. Nuclear reactions can change matter into energy and vice versa. The total quantity of matter and energy is conserved.	a. analyze the amount of energy contained in the mass of substance (1.2; 1.3; 1.6; 3.5; 4.1)	• Compare the energy released from 1 gram of a substance burned as a chemical fuel to the energy available if the same mass were converted to energy through nuclear decay ($E = mc^2$).
6. Solar energy travels through space, is distributed on Earth by radiation, conduction, or convection, and powers atmospheric and oceanic circulation.	a. explain how the transfer of energy by air and ocean currents regulate the physical environment of the Earth (1.2; 1.3; 2.1; 2.4; 3.3; 4.1)	• Investigate and describe the effects of world atmospheric circulation or oceanic circulation on the temperatures of different parts of the world.

SCIENCE 9–12

IV. FORCE, MOTION AND MECHANICAL ENERGY
(SHOW-ME STANDARDS, SCIENCE 2)



A. Relative Motion
B. Types and Properties of Forces and Motion
C. Interactions of Forces and Motion

K-12 Content Overview:

Motion is as essential to understanding the physical world as matter and energy. Nothing in the universe is at rest and even things that appear to be at rest move. The description of how objects move depends on the frame of reference, but everything moves with respect to the sun and stars. Motion is described in terms of distance, displacement, speed, velocity, and acceleration. There are different types of motion, each with important properties, that can be combined into more complex forms. Types of motion include constant speed in a straight line, constant speed in a circle, acceleration in a straight line, and acceleration in a circular path. Relationships among these quantities are more easily interpreted and used to solve problems by means of graphical techniques involving slopes and areas under curves.

Four fundamental types of forces exist in the universe: gravitational, electromagnetic, strong nuclear force, and weak nuclear force. All other forces can be classified in terms of these four. Changes in the motion of objects are due to the effects of these forces. The size and direction of a force are important in order to determine the effect on the motion of an object. More than one force can act on an object at the same time and can make things move or keep them from moving, depending on the frame of reference.

IV. Force, Motion and Mechanical Energy A. Relative Motion

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. An object's position can be described relative to another object (above, below, left of, right of, behind, or in front).	a. describe the position of an object relative to another object (1.8; 1.10)	• Describe the position of a student's desk in relation to the teacher's desk or another student's desk.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
2. An object's motion can be described in terms of another object (e.g., faster, slower) and how its position changes over time.	a. compare one object's position and motion relative to another object (1.6; 3.2; 3.3)	• Describe an object's motion and position (in 5-second intervals) relative to a fixed point and relative to another moving object.

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Forces explain many kinds of motion (e.g., stopping, starting falling, straight, zigzag, circular, vibrational).	a. express ideas on the type of motion an object is undergoing (2.1; 2.4)	• Observe and describe the motion of a feather, guitar string, merry-go-round, swing, etc.
2. Force is any push or pull exerted by one object on another.	a. identify the forces on a moving object and predict the direction it will go (1.6)	• Describe the forces acting on a ball thrown straight up. • Describe the forces acting on a moving toy and predict the movement it might take.
3. Weight is a measurement of the attraction of gravity on a mass. Mass is the amount of matter of an object.	a. use the appropriate tools to weigh an object then find its mass (1.4; 1.6; 3.3)	• Use a scale to weigh an apple; use a balance to mass the same apple; compare numbers. Repeat with other objects.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
4. Forces can be mechanical, gravitational, magnetic, or electrostatic.	a. demonstrate the force of gravity by using a scale (2.1; 3.7; 4.1)	• Prepare a demonstration using a scale to measure the effects of gravity on common objects.
	b. design and conduct inquires to study the effects of an electrostatic force on the motion of an object (1.3; 1.6)	• Use a comb and pieces of paper to demonstrate electrostatic force.
	c. demonstrate and investigate magnetic force fields (1.1; 1.2; 1.3; 1.4; 1.6; 2.1; 2.3; 3.2)	• Use a bar magnet and iron filings in a plastic bag to demonstrate a force field. Sketch the field lines.

IV. Force, Motion and Mechanical Energy C. Interactions of Forces and Motions

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Magnets attract and repel each other and certain kinds of metals.	a. work as individuals and collaborate with others to identify the materials that are attracted to a magnet (3.2; 4.6,)	• Observe the effect of one magnet on another and on other objects.
2. The movement of an object depends on the force applied and how much mass it has.	a. identify and analyze how much force is needed to move a variety of objects (1.6; 2.4; 3.3; 3.5; 4.1)	• Using various objects in the classroom, determine which are easier to move.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
3. An unbalanced force causes an object to change speed or direction. The magnitude of the change in speed or direction depends on the amount of force applied and the mass of the object.	a. evaluate data and describe the relationship of the amount of force applied to an object, the mass of the object, and the amount of change in the object's motion (1.4; 1.6; 2.5; 3.1; 4.1)	• Explore how objects of various mass travel different distances down an inclined plane. Predict where a new object (mass) will stop based on the collected data. • Analyze the forces on a thrown ball to formulate strategies to predict the direction and distance of the ball.
4. Simple machines are used to change the direction of an applied force and provide the mechanical advantage needed to move objects.	a. analyze and evaluate the way a simple machine increases the applied force (1.1; 1.2; 1.3; 1.6; 2.1; 2.5; 4.1)	• Describe how forces work in common simple machines (e.g., seesaws, crowbars, slides). • Discuss the mechanical forces used in everyday tasks (e.g., riding a bike, swinging in a swing) and identify the forces and motions involved and how they change.

IV. Force, Motion and Mechanical Energy A. Relative Motion

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The motion of an object can be described as a change in position, direction, and speed.	a. use appropriate technologies to measure and compute the direction and magnitude of the forces causing the motions of common activities (1.1; 1.3; 1.4; 3.5)	• Describe the position, direction, and speed of a person in an elevator with respect to someone else in the elevator and with respect to someone on one floor of the building.
2. The motion of an object can be represented graphically in terms of direction over time, speed over time, or position over time.	a. organize a date concerning the direction and position of a moving object with respect to time in graphical form (1.1; 1.2; 1.4; 1.8; 3.1; 3.5)	• Determine the speeds of objects (e.g., students running, walking, riding a bike) using measurements of distance and time. Compare the results both numerically and graphically.
3. Acceleration occurs when an object speeds up, slows down, or changes direction.	a. explain how an object's acceleration is affected by outside forces and its mass (3.1; 3.3; 4.1)	• Describe the acceleration of a race car as it runs the race course. • Explain, in terms of outside forces, how an object may change its direction or acceleration.

IV. Force, Motion and Mechanical Energy B. Types and Properties of Forces and Motion

By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The overall effect of many forces acting on an object at the same time is called net force. The size and direction of this net force determines the change in motion of an object.	a. use technologies to determine the direction of acceleration and the net force for an object moving in a circle (1.3; 1.4; 1.6; 1.10; 4.1)	• Define and discuss the forces and acceleration involved when an object changes direction. • Identify the forces involved and determine the net force of a person sitting in a chair. Predict what would happen if the forces were changed.
2. Whenever an object exerts a force on another, an equal but opposite force is exerted back on it.	a. recognize and define the forces necessary for an object to move or be in equilibrium (1.4; 1.7; 2.1; 3.5; 3.7; 4.1)	• Using a model airplane, explain forces that allow it to fly.
3. Every object exerts a force on every other object. Its magnitude depends on the masses of the objects and the distance between them.	a. compare and describe the gravitational force between two objects (1.4; 1.7; 2.1; 3.1; 4.1)	• Explain, in terms of the forces involved, why a satellite orbits Earth. • Compare the gravitational force of one object to another that has a mass 100 times greater.

IV. Force, Motion and Mechanical Energy C. Interactions of Forces and Motions

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Mechanical energy comes from the motion (kinetic energy) and/or position (potential energy) of an object.	a. interpret and explain the relationship among kinetic energy, potential energy, and mechanical advantage (1.6; 1.8; 2.1; 2.3; 2.5; 4.1)	• Determine the amount of mechanical energy necessary to turn a flywheel of a car's engine. • Explain and demonstrate the types of energy, changes in motion, and mechanical advantage involved in shooting an arrow.
	b. analyze the changes in kinetic and potential energy in common activities (1.5; 4.1; 4.10)	• Determine the amount of potential energy in a water tower.
2. The work done on an object depends on both the applied force and the distance an object moves.	a. determine the amount of work done when an object is moved or when a task is performed (1.5; 4.1; 4.10)	• Compare the amount of work done in mechanical or electrical devices.
3. Simple machines can be used to change the force on an object, its speed, or its direction of movement.	a. explain and demonstrate how common tools are simple machines and discuss the forces and motions involved (1.1; 1.6; 1.10; 3.1; 3.6; 4.1)	• Give examples of simple machines found in the human body and explain the mechanical advantage they provide. • Compare the masses of several objects and the distances from the fulcrum of a balanced lever. Predict the unknown mass of an object hanging on the fulcrum. • Determine the amount of force necessary to lift objects with different types of pulleys.

IV. Force, Motion and Mechanical Energy A. Relative Motion

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Motion can be described in terms of velocity and acceleration and be represented by equations and vectors.	a. represent and analyze motion both quantitatively and graphically using velocity and acceleration (1.8; 2.4; 3.5; 4.1)	• Determine the effects of wind on the flight of a plane and communicate those conditions with vector diagrams. • Describe the flight path of an arrow in terms of its acceleration.

IV. Force, Motion and Mechanical Energy B. Types and Properties of Forces and Motion

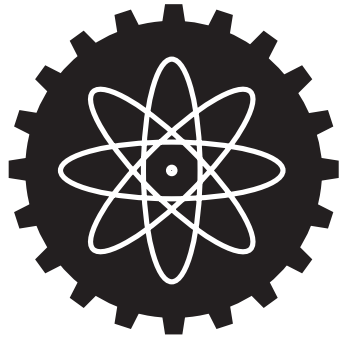
What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The acceleration of an object is related to its mass and the force acting on it.	a. analyze information from inquires to interpret the effects of forces on velocity, acceleration, and equilibrium of an object (1.2; 1.4; 1.7; 3.5; 3.7; 4.1)	• Determine the weight of an object in Newtons. • Analyze the types of forces and motions of several amusement park rides for possible structural problem.
2. The action of all forces can be explained by Newton's Laws of Motion that are used to predict changes in linear and/or rotational motion.	a. evaluate information to describe how Newton's Laws of Motion are used to describe moving objects (1.7; 2.4; 3.4)	• Conduct measurements and calculate the retarding force of the brakes of a car, train, truck, etc.
3. Moving electric charges produce magnetic fields that exert a magnetic force on other objects; moving magnets can produce electric forces.	a. select and apply appropriate strategies to investigate the relationship between a magnetic force and an electric current and devise a practical application using this relationship (1.6; 1.10)	• Design, construct, and demonstrate an electromagnet capable of lifting several Newtons. • Examine the process of induced polarization. Create models to account for what is observed. • Investigate the relationship between magnetic force and electric current. • Devise an experiment to generate an electric current using a wire and a magnet.

IV. Force, Motion and Mechanical Energy C. Interactions of Forces and Motions

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. A force acting on an object, moving it through a distance, can change its kinetic energy, potential energy, or both.	a. describe the forces acting on a moving object that changes the object's kinetic and potential energy (1.6; 1.10; 3.5; 4.6)	• Analyze and describe the changes in kinetic and potential energy that take place when a basketball player dribbles or shoots the ball.
2. The ratio of output work to input energy is the efficiency of a machine or process and is always less than 100%. Power is the rate at which work is done.	a. analyze and describe the relationship among work, power, and efficiency (1.6; 1.10; 2.4; 3.4; 4.1)	• Collect data and organize information to analyze the work, power, and efficiency of a refrigerator.
3. The Law of Conservation of Momentum can be used to predict the outcome of collisions.	a. evaluate information to describe and discuss the result of a collision between two or more moving objects (1.6; 2.3; 3.8)	• Predict and discuss the results of the collisions of a cue ball with one or more billiard balls.

V. UNIVERSE
(SHOW-ME STANDARDS, SCIENCE 6)

A. Characteristics of the Universe
B. Motions of the Universe
C. Tools of Space Exploration



K-12 Content Overview:

Students today are growing up in a world of space travel and exciting new discoveries. Studying the universe helps students understand both the nature of the universe and the important contributions space exploration has made to our understanding of the universe and humankind.

The universe contains billions of galaxies, each of which contains billions of stars of various types. Our solar system, located near the edge of one galaxy, contains a very important star (the sun), planets, moons, asteroids, and comets.

By observing the sky on a regular basis, elementary students learn to identify changes and patterns. Observations of these changes and patterns help children understand and describe what is happening in the universe. Knowledge of the universe and the Earth's position in it provides students with a sense of time and place. The Earth's location and motion in relation to that of the sun and moon cause significant changes in the Earth's physical environment. Because direct experimentation is not possible for testing most concepts related to the universe, students must rely on data collected through technology, which, in turn, requires students to develop sequential thinking skills and the ability to follow logical multisteps to draw conclusions and make predictions.

By the middle level, students identify the characteristics of stars, their composition and distance. Current models of the universe used by high school students are based on mathematical and computer simulations.

Patterns, positions and distances of celestial objects are observed and measured with the use of telescopes and satellite images. The impact of technology on data gathering, prediction, and knowledge challenges students to follow the multistep logic necessary for understanding .

V. Universe A. Characteristics of the Universe

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Earth is not alone in the universe. Most of the objects in the universe are separated by enormous distances.	a. present ideas and opinions about the relationship of the sun and moon to Earth and Earth's position in the universe (2.1) b. describe the major components of our solar system (1.3; 1.8)	• Draw a picture of the relative positions of the Earth, moon, and sun. • Use scaled objects at different distances to model the solar system and show the distances between and sizes of the planets.
2. The sun, moon, and stars have recurring patterns.	a. evaluate information about the sun and moon and share to determine patterns, changes, and relationships (1.2; 1.6; 3.5)	• Identify patterns and changes in the sun, moon, and stars.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
3. Constellations are patterns of stars.	a. identify the major constellations and determine the seasonal changes in patterns (4.6) b. research and report on the legends of major constellations (1.4; 1.8; 2.1)	• Observe the night sky over an extended period of time, keeping a record or chart of the observations to identify the major constellations. • Script a play about the major constellations based on legend.
4. Earth is in our solar system and has unique properties.	a. compare and contrast Earth's properties to other planets in our solar system (1.2; 1.6)	• Identify some characteristics of Earth that allow it to support life.
5. Earth rotates on a tilted axis and revolves around the sun. This combination causes changes in the amount of sunlight reaching the Earth's surface and makes our seasons.	a. explain how Earth's movements and tilt cause seasons (1.4; 2.1; 2.7)	• Model a demonstration of the tilt of Earth's axis in relation to the place of the orbit around the sun and use it to explain seasons at different places on the Earth.

V. Universe B. Motions of the Universe

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Objects in the sky move.	a. use senses to gather information about the day sky through regular observations (1.3; 1.6; 2.3)	• Observe and measure the shadow of a specific object at different times of the day, and determine the direction of the shadow points in relation to the position of the sun.
2. Earth makes a full rotation on its axis every 24 hours that causes the day/night cycle.	a. explain the relationship of the rotation of Earth and the day/night cycle (1.2; 1.7; 2.3; 3.5; 4.1)	• Use a ball and a light source to demonstrate the cycle of night and day and the rotation of Earth.
3. Patterns of movement of some objects in the sky are cyclic.	a. discover and evaluate patterns in the sky (1.6; 3.5; 4.1)	• Record observations of the day and night skies over an extended period of time and identify patterns of movement.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
4. The motion and positions of objects in the solar system are observable phenomena that can be explained.	a. evaluate information about the motion and position of Earth, moon, and sun to determine the patterns that give us our day, month, year, moon phases, and eclipses (1.6)	• Demonstrate the positions and motions of the sun, moon, and Earth to explain moon phases, solar eclipse, and moon eclipse.
5. Recurring predictable movements of the Earth and moon can be used to measure time.	a. explain how time can be based on the movements of Earth in relation to the sun, moon and stars (1.3; 1.6; 1.8; 2.7; 4.6)	• Make a working sundial and explain how it was done. • Construct and use a Big Dipper star clock.
6. Different constellations can be seen in different seasons.	a. explain why certain constellations can be seen only at certain seasons (1.6; 2.4; 3.5; 4.1)	• Illustrate how the Earth's position relative to the sun determines which constellations are visible in different seasons.
7. The sun, moon, stars, and planets appear to move from east to west each day	a. explain the reasons for different time zones (1.2; 3.5; 4.1)	• Chart the times and directions of sunrise and sunset over a 2-month period in two different time zones.

SCIENCE K–4

V. Universe C. Tools of Space Exploration

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Special clothing and equipment must be used by people who travel into space.	a. explain the use of different clothing and equipment used by people who travel into space (1.5; 1.6)	• Compare and contrast the clothing and equipment used during early and current space explorations.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
2. Telescopes and satellite imaging allow scientists to observe features and structures of some objects in the sky.	a. identify prominent features of Earth and planets (1.4)	• List obvious features of the moon and Earth from some NASA photographs and satellite images. Name some things that can be learned or predicted from studying these images.
3. Space exploration has provided many benefits to humankind.	a. identify and explain some ways that food, clothing, or machines have changed as a result of the U.S. space program (1.2; 3.6; 4.1; 4.7)	• Investigate the impact that space technology has had on food preservation.

V. Universe A. Characteristics of the Universe

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The universe is so large that its distances are expressed in special units (i.e., light years, astronomical units).	a. use visual and mathematical aids to determine the approximate locations of stars in the constellations (1.4; 2.2)	• Design and construct a planetarium that models the constellations in the northern hemisphere. • Use scale drawings to determine the distance between Earth and the moon. Explain how these methods can be used to estimate astronomical distances and how linear measurements convert to light years.
	b. create a model in which the same scale is used to depict the distances between objects and calculate the time required to travel a direct path to them from Earth (1.6; 2.1)	• Describe the relative sizes of the planets (as viewed from Earth) and their distances from the sun.
	c. interpret and evaluate information related to distances from our solar system to other points in our galaxy and the universe (1.2; 1.7; 2.7; 3.5; 4.1)	• Use triangulation to determine the distance between specific points on Earth. Explain how this method can be used to estimate astronomical distances.
2. Celestial objects possess both similarities and differences.	a. use a variety of resources to compare and contrast the physical properties of planets (1.8; 3.5; 2.3)	• Use NASA photographs and satellite images to compare the size and surface features of the planets and their moons. • Create an itinerary of a space vacation that describes what will be seen at different stops along the way.
3. Our solar system is part of the Milky Way Galaxy, one of many galaxies in the universe.	a. use a variety of visual aids to locate the position of the solar system in the Milky Way Galaxy (1.5; 1.6; 2.2; 2.3; 4.1)	• Use photographs to approximate the location of the solar system in the Milky Way Galaxy.

V. Universe B. Motions of the Universe

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The force of gravity determines the orbital patterns of celestial objects.	a. conduct an investigation that demonstrates planetary orbits and apply the processes and knowledge learned to patterns within the solar system (1.3; 1.6; 3.5)	• Use ball bearings with different strengths of magnets to simulate planetary orbit patterns.
2. Earth is a moving planet that has unique features.	a. use a variety of methods, forms, and technologies to describe Earth (1.4; 2.7; 3.5; 4.1)	• Analyze satellite data or perform sun angle measurements to test the assumption that Earth is spherical and rotates on its axis.
3. Earth rotates on tilted axis as it revolves around the sun causing sunlight to hit at different angles. The revolution and tilt produce seasonal variations in weather and climates.	a. evaluate how revolution, rotation, and tilt of the Earth influences the amount of sunlight that reaches the surface (1.7; 1.8)	• Build models to demonstrate and predict the seasons in different hemispheres of Earth at a given time. Chart this information and compare the results to weather patterns in Missouri throughout the year.
4. Moon phases and eclipses result from the angle from which we view the moon.	a. explain such phenomena as lunar and solar eclipses and moon phases (1.6; 2.4; 2.5)	• Monitor the position and phases of the moon for a complete cycle, and construct a sun/moon/Earth model to explain the observations.
5. Nine planets, their moons, comets, asteroids, and meteorites orbit the sun.	a. explain how planetary orbits are affected by gravitational forces of other planets and the sun (1.5; 1.7; 3.3; 4.6)	• Use scale models of the solar system to demonstrate the relative sizes of the planets and their moons, as well as their distances from the sun, and the primary orbits.

V. Universe C. Tools of Space Exploration

By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. A variety of technological tools are used to provide information concerning the physical properties and conditions of the solar system.	a. discuss how information received from space probes has either confirmed or modified scientific theories concerning conditions on other planets (1.7; 2.4; 3.1; 3.5; 4.1)	• Select a space probe mission and research what type of information these robotic explorers have provided about the solar system. Discuss how this information has either confirmed or modified scientific theories about other planets.

V. Universe C. Tools of Space Exploration

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
2. Most information about the universe comes from the electromagnetic spectrum.	a. use an illustration of the electromagnetic spectrum to describe the relationship between wavelength, energy, and frequency (1.4; 2.7; 3.5; 4.1)	• Use full electromagnetic photograph to view objects in the sky to see a wide range of features and information.
3. Research associated with space exploration has resulted in technological advances that have affected the quality of life.	a. identify common products that have been developed as a result of research associated with space exploration	• Collaboratively make a list of everyday items that are spin-offs from the space program.

V. Universe A. Characteristics of the Solar System

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The current model of the universe was developed from evidence about its content and theoretical assumptions based upon mathematical and computer-simulated models.	a. present organized arguments and opinions about the various scientific theories on the formation of the universe (2.4)	• By inflating a balloon which is covered with dots, demonstrate that from any perspective the expansion of the universe results in spreading points. Support this expanding universe idea with actual photographs and data from NASA. • Compare Earth's chemical composition, size, and position in the solar system to those of other planets. Based on this comparison, discuss and debate the possibility of the existence of life on other planets.
2. Stars appear to go through a cycle of birth, development, and death.	a. use information about a star's characteristics to determine its age (1.6; 3.5)	• Explain how scientists have used information about a star's size, composition, mass, surface features, and temperature to develop models of stellar evolution.
3. Because of the vast distances between objects in the universe, light may take billions of years to reach Earth.	a. explain the different units used to measure distances by astronomers and explain why they use them.	• Calculate the length of time it takes for light to travel from the sun to Mars.

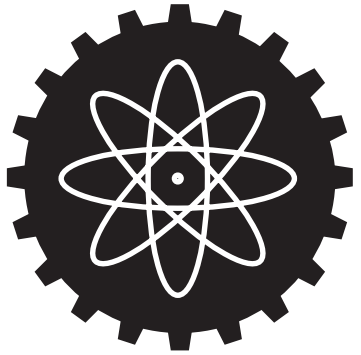
V. Universe B. Motions of the Universe

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Newton's conception of the universe established the idea that the laws which apply to processes that occur on the Earth also apply to the universe.	a. evaluate information and products to determine the relationship of Newton's Laws in space and on Earth (1.3; 1.5; 1.7)	• Examine NASA simulations to gather data that demonstrate Newton's Laws. • View a "Star Wars" movie and identify applications and misapplications of Newton's Laws.
2. Gravitational laws explain planetary motion and tides.	a. develop a logical description of how gravitational laws explain the movement of planets and tides (1.6; 2.4; 3.5; 4.1)	• Apply the laws of gravitation to explain why planets closer to the sun must move faster and planets farther from the sun move slower.

V. Universe C. Tools of Space Exploration

By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Space exploration has expanded our knowledge of the universe and advanced the technological sophistication of our society.	a. identify and explain ways society has benefited from the technologies developed through space exploration (1.1; 1.2; 1.4; 1.7; 1.9; 1.10; 2.7; 2.2; 3.5; 4.1; 4.6)	• Research the history of the space program and explain the technologies used in getting people and equipment into space.
	b. evaluate the economic impact of the space program (1.1; 1.2; 1.4; 1.5; 1.7; 1.8; 2.1; 2.3; 3.5; 4.1; 4.6)	• Research how the development of new materials, computers, flight designs, etc, for space exploration has benefited society economically.

VI. EARTH SYSTEMS
(SHOW-ME STANDARDS, SCIENCE 5)



A. Physical Systems
B. Processes of Systems

K-12 Content Overview:

Knowledge of the processes and physical nature of Earth provides students with a picture of Earth's past, present, and future. The physical laws that have governed the entire universe in the past are the same as those that govern material interactions today. Earth's physical systems, comprised of subsystems (biosphere, atmosphere, hydrosphere, and lithophere) , are continuously interacting with one another. Changes in each of the subsystems impact Earth's physical and biological characteristics.

The processes on Earth, such as the movement of plates and the flow of air and water, are driven by heat energy from within the Earth and by heat generated when sunlight strikes the atmosphere and surface of Earth. Interactions between heat and other forms of energy with matter on Earth shape its surface, determine its climate, affect its atmosphere, and set the stage for life. Earth provides humans with the resources they need to sustain life and to advance technologically; however, as people use these resources, they have also altered Earth systems. Questions of environmental policy should be pursued when students become aware of these related issues.

VI. Earth Systems A. Physical Systems

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Water reaches Earth in different forms (snow, hail, rain, fog, etc.).	a. conduct research to develop and evaluate information and ideas about how water in various forms reaches Earth (1.2; 1.6; 3.5)	• Use a globe to identify different areas that would have lots of or very little rain, snow, fog, etc.
2. Earth's natural resources are limited.	a. conduct research to develop and evaluate information on the use and abuse of Earth's natural resources (1.2; 1.9)	• Construct posters that promote responsible use of water or trees.
3. Earth's surface is composed of rocks, soils, water, and living organisms. Differences in these components can be used to classify them.	a. apply knowledge and skills to classify a variety of rocks or soil (1.10; 3.5)	• Collect a variety of rocks or soil and classify them according to one type of physical property.
4. The atmosphere has physical properties that are measurable and predictable.	a. conduct research to develop and evaluate information about the atmosphere; plan and make a written, oral, and visual presentation of the patterns of change over a period of time (1.2; 1.4; 1.8; 2.1)	• Keep a journal of temperatures and weather conditions for a month or two. Identify patterns • Compare the seasonal changes and describe how humans have adapted to them.

VI. Earth Systems A. Physical Systems

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
5. Fossils provide evidence of plants and animals that lived long ago and the environment in which they lived.	a. plan and make a written, oral, and visual presentation about the natural history of our state based on evidence of fossils found in Missouri (1.3; 1.8; 1.9; 2.1)	• Compare and contrast the Missouri environment of today to that of long ago through fossil evidence. • Compare the similarities and differences between fossils and living organisms. Ask reasonable questions about those comparisons.
6. Water is a valuable natural resource essential to all life.	a. exchange information and ideas with others about water conservation and the essential need for water by all living things while recognizing different points of view (1.4; 1.8; 2.3; 2.7)	• Survey family and friends to see how many ways they use water. Compare findings with classmates and classify essential uses.
7. Rocks, minerals, and soil have physical characteristics by which they can be classified.	a. classify rocks, minerals, and soils according to their physical characteristics (1.6; 1.8)	• Classify a given group of rocks according to color.
8. Soil composition varies from location to location and affects the type of plants that grow in that location.	a. use technological tools and other resources to locate, select and organize information from simple investigations to determine which plants grow best under various conditions in a variety of locations (1.4; 1.6; 3.5)	• Create and conduct simple investigations to determine what plants will grow best in different kinds of soil.

VI. Earth Systems B. Processes of Systems

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Water is stored all over Earth.	a. discover and evaluate patterns and relationships in information to predict and identify areas that store water (1.3; 1.6; 2.4; 3.5)	• Identify areas of Missouri that store water above and below ground.
2. Rocks change over time by weathering.	a. conduct research to develop and evaluate information to show how rocks change over time by weathering (1.2; 1.6; 1.8; 2.4; 3.5; 4.1)	• Observe and describe signs of weathering on a brick building, statue, bridge, cliff, etc.
3. Earth's rotation causes a day and night cycle.	a. identify the apparent position of the sun throughout the day (1.3; 1.6; 2.3; 3.1; 4.6)	• Using sticks in the ground, mark the position of the shadows during a sunny day. Describe what is observed.
4. Seasons and changes in weather affect human and animal activity and plant growth.	a. apply the knowledge and skills learned from weather observation and investigations to study the effect on human and animal activity and plant growth (1.3; 1.6; 1.10; 3.2; 3.3)	• Compare the different weather patterns in northern and southern parts of the United States. Discuss how these patterns influence plant growth and human activity in those states.
5. The surface of Earth changes slowly (e.g., erosion, weathering) or quickly (e.g., earthquakes, floods, rock/mud slides, volcanic activity).	a. present perceptions and ideas on ways the surface of Earth changes slowly or quickly (2.4; 4.1)	• Choose a natural disturbance (flood, heat wave, snow, ice storm) and identify the changes it caused and how it affected plants, animals, and humans.

VI. Earth Systems B. Processes of Systems

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
6. Water condenses, evaporates, and exists as a gas liquid or solid on Earth and in the air.	a. develop strategies for predicting and addressing the effect of temperature or wind on evaporation and condensation (2.4; 3.2; 3.3)	• Conduct investigations to determine the effect of temperature or wind on evaporation and condensation.
7. Earth's surface features are continually changing.	a. select and apply problem-solving strategies using prior knowledge and experiences to show how and where Earth's surface is continually changing (1.10; 3.2; 3.3)	• Use globes and maps to identify major geological features. Compare Missouri's features to those in other states. • Choose a local area that has undergone changes due to erosion, wind, or plant/animal/human activity. Identify these changes as slow or rapid.

VI. Earth Systems A. Physical Systems

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The atmosphere is composed of a chemical mixture of gases, water vapor, and minute particles.	a. use appropriate technology and other resources to select and organize information about atmospheric properties (1.4)	• Given data on variations of atmospheric composition, explain changes in the atmosphere over a period of time and predict possible future scenarios.
2. Properties of the atmosphere are observed and measured to predict weather changes.	a discover and evaluate patterns and relationships in the properties of the atmosphere and their structure; develop strategies to predict weather changes (1.7; 3.2)	• Use appropriate technology and weather maps to record weather data for 2 months. Identify any patterns and predict the weather for a week.
3. Rocks and minerals can be classified by their chemical and physical properties.	a. conduct research using chemical testing and evaluate the information to classify a variety of rocks and minerals (1.2; 1.6; 3.5)	• Group rocks and minerals according to properties determined by chemical tests.
4. Surface and subsurface rock and mineral deposits lead to the determination of age, origin, and events in Earth's history.	a. use appropriate technology and other resources to locate, select, and organize information to determine relative age of mineral, rock, and soil samples or associated events that may have occurred (1.4; 1.6; 1.10)	• Research how rock composition, layering, and physical structure reflect the geologic history of an area.
5. Formation of layers of sedimentary rock and their associated fossils confirm the long history of Earth and its changing lifeforms.	a. construct models and geological profiles to demonstrate the age relationship of sedimentary rock layers (1.8)	• Analyze information from field research of a nearby road cut, stream bank, or ditch to interpret the sequence of rock layering and relative age.
6. Surface and subsurface water replenish each other. Human activity and natural events can affect the quality of the supply.	a. organize data, information, and ideas about human activity and natural events that affect the quality of water supplies for analysis and presentation (1.8)	• Research the impact of human activity on the Missouri and Mississippi Rivers. • Determine the amount of surface water stored in Missouri. How much water do Missourians use in 1 day? Relate the two.

VI. Earth Systems A. Physical Systems

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
7. There is economic value in Missouri resources, both above and below ground.	a. reason inductively about Missouri's mineral deposits and their relationship to the economy and deductively about environmental concerns—past, present, and future (3.5)	• Identify major resources in Missouri and their annual value from products (lead, iron, limestone, etc.). • Compare and contrast present day maps, land images, and aerial photographs of Missouri to those of the past. Identify any changes that have occurred in the topography of Missouri and investigate reasons for the change.
8. Earth has three distinct physical spheres: atmosphere, hydrosphere, and lithosphere. Each has different compositions yet interfaces with each other.	a. collaborate with others in developing and clarifying perspectives by applying knowledge, measurement, and concepts of the hydrosphere, lithosphere, and atmosphere (2.4; 4.6)	• Describe how soils influence the agricultural productivity and economy of the area. • Construct a closed system terrarium with standing water and multiple lifeforms and make ongoing observations of the cycling of water and/or other substances.
9. The benefit of resources from Earth's physical spheres can be reduced by deliberate or inadvertent misuse or destruction.	a. using appropriate technology, identify, analyze, and evaluate causes of pollution and its effect on an area; use this information to create a model demonstrating the complexity of pollution (1.4; 1.6; 1.8; 2.4; 3.5; 4.1)	• Use maps, satellite imagery, instrumentation, etc., to locate possible sources of atmospheric pollution. Compare sources with meteorological data to locate possible origin of local contamination.

VI. Earth Systems B. Processes of Systems

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The water cycle is driven by energy transfer processes, such as convection and radiation, and is constantly changing the location and phase of water.	a. exchange information, questions, and ideas with others to discuss the effects of energy transfer on the water cycle (2.3)	• Construct a model to demonstrate the processes of the water cycle. • Design simple experiments to demonstrate the influence of wind and temperature on the hydrologic cycle.
2. Large bodies of water have a major effect on weather and climate. Ocean currents are caused by differences in temperature and salinity.	a. organize data, information and ideas into useful forms for analysis and summary to predict climatic patterns associated with large bodies of water (1.8)	• Examine maps of ocean currents to trace their origin and flow. Explain the transport of heat energy in these currents.
3. The surface of Earth has changed as a result of dynamic forces originating within the mantle. The physical evidence (faulting, volcanoes, folding of rock, etc.) of these constructive and destructive forces is associated with plate movement.	a. conduct an investigation to develop and evaluate information and ideas concerning the theory of plate tectonics; use landform models and maps to analyze the distribution of global features and geological phenomena such as volcanoes and earthquakes (1.3; 1.8)	• Demonstrate how forces on materials cause wrinkles, folds, and faults. • Plot the location of earthquakes, volcanoes, trenches, and oceanic ridges to identify patterns of evidence for the existence and movement of crustal plates.
4. Properties of soil and the hydrology of surface and groundwater have physical and cultural impact standpoints.	a. conduct research to develop and evaluate information and ideas of the human impact on water resources (1.2) b. design and conduct field or laboratory investigations to study types of soil; recognize how the different types of soil lead to differences in drainage, percolation for septic systems, and groundwater quality (1.3; 1.6; 3.1)	• Identify a source of contamination using a model designed to simulate groundwater testing methods and discuss challenges to locating and cleaning underground contamination. • Identify a local watershed and determine the factors that influence the replenishment of the groundwater supply.
5. Incoming solar radiation and the hydrologic cycle create patterns of weather and climate.	a. design and conduct investigations to study the effects of solar radiation, tilt of the Earth's axis, and the water cycle on patterns of weather and the climate on Earth (1.3)	• Design and construct an experiment using a sphere, light source, and measurement tools to collect data on solar radiation and weather.

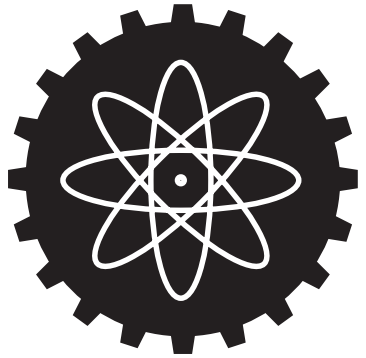
VI. Earth Systems A. Physical Systems

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Variations in the physical conditions and chemical composition of soil are a result of the type of rock from which it came, climate, the process by which it was deposited, and biological activities.	a. discover and evaluate the patterns and relationships of the soil to the origin of the local rock type, climate, processes of deposition, and biological activity (1.6)	• Relate how composition and physical structure of soil reflect local geology by comparing soil maps to geological maps. What would you find in the northern, glaciated portion of Missouri?
2. Changes in the atmosphere can be caused by natural or human activities.	a. identify and describe the scope of the impact of human activity on the atmosphere (3.1)	• Research and report the impact human activities have on the atmosphere (car exhaust/breathing problems, industrial emissions/acid rain, etc.).
3. Variations in composition of the atmosphere and hydrosphere caused by natural activities affect all life on Earth.	a. investigate information on several natural disasters and predict possible reactions of plants, animals, and humans (1.3; 1.6; 1.8; 2.3; 3.5)	• Study the effects of a recent volcano eruption on the atmosphere. Develop a timeline of the dust flow around Earth and predict possible reactions of plant, animal and human behavior.
	b. use appropriate technology and other resources to locate, select, and organize information about natural disasters and their effect; develop strategies to predict occurrences and/or reduce or solve the resulting problems (1.4; 3.2)	• Using library and Internet sources, identify and research a natural event that has affected the atmosphere and/or hydrosphere. Participate in a discussion on the Internet addressing possible actions that might reduce the effect.

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Elements cycle through the atmosphere, hydrosphere, lithosphere, and biosphere. The movement of matter through the spheres is driven by Earth's internal and external sources of energy.	a. conduct research to develop and evaluate information on the movement of matter through a model ecosystem (1.2)	• Conduct an ongoing investigation, accompanied by research, utilizing a worm farm, isopod colony, or other habitat to gather information on movement of matter through systems.
2. Crustal plate movement affects Earth's topography and provides evidence of a geologic time scale.	a. using a variety of models and other resources, design and conduct an investigation to study Earth's energy sources; apply the processes and knowledge learned to understanding changes in Earth's surface (1.3; 1.6; 3.2; 3.3; 4.1)	• Construct a model of convection currents that involves collecting quantitative data.
	b. use appropriate technoloy to locate, select, and organize information related to a plate movement; conduct research using a simulation of that event and evaluate the information (1.2; 1.4)	• Study the p-waves and s-waves of a computer-simulated earthquake to locate the epicenter.
	c. identify the theories associated with major geological events and present the information in the form of a time line (3.1)	• Construct a diagram, 3-D model, or AV simulation that shows the position of crustal plates at different times in Earth's history. Establish links that support these crustal positions.
3. Circulation of air and water around Earth, driven by radiation energy from the sun, causes weather phenomena and regional climate.	a. discover and evaluate the patterns and relationships in the circulation of air and water around Earth, how they are driven by radiation energy from the sun, and how this causes weather phenomena and regional climates (1.6)	• Construct climatograms and examine world and regional maps showing climatic zones to compare the effect of different variables on the climate of an area. Identify areas that would be expected to have climates similar to and different from Missouri.
		• Investigate the differential heating rates of soil and water and collect and graphically represent data for inland vs. coastal area.

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
4. Science technology has enhanced our ability to detect atmospheric changes resulting from interactions of Earth's systems.	a. use appropriate technology to locate and select patterns of global and local weather and climate changes resulting from interactions of Earth's systems (1.4)	• Explore how technology (weather satellites, Doppler radar, aerial photographs, Landsat imagery) has enhanced our understanding of atmospheric changes and land use.

VII. LIVING SYSTEMS
(SHOW-ME STANDARDS, SCIENCE 3)



A. Structures/Function/Characteristics
B. Life Processes
C. Diversity
D. Reproduction/Heredity
E. Adaptation/Evolution

K-12 Content Overview:

Observation and classification of living things began with the need of the earliest humans to survive. Human curiosity and desire to organize have led to systems that classify the complex diversity of life based on knowledge of external features, behaviors, internal structures, and molecular evidence. Understanding and appreciating the diversity of life comes from students' ability to see the patterns of similarity and differences that permeate the living world. The living environment consists of millions (perhaps tens of millions) of different types of organisms, all of which carry out the same basic functions that have maintained life for millions of years. The information required to carry out the life functions is encoded in chemicals in the nuclei of cells and is passed from generation to generation. A complex interplay between variations in the genetic code and environmental factors results, over time, in changes in living organisms.

The challenge for educators is to capitalize on the interest that students have in living things while moving them gradually toward ideas that make sense out of nature. Familiarity with the phenomena should precede their explanation, and attention to the concrete object should precede abstract theory. (The "Functions and Interrelationships of Systems" strand within the Health/Physical Education framework contains content related to body systems.)

VII. Living Systems A. Structure/Function/Characteristics

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Observable characteristics of living organisms can be used to sort and group them.	a. sort common objects based on color and/or shape and use this skill to sort common organisms (1.5)	• Observe and compare similarities and differences in mature and immature organisms (dogs/puppies, frogs/tadpoles, trees/saplings).
	b. discover and evaluate patterns and relationships of living organisms (1.6)	• Sort common organisms based on one or two physical characteristics such as color, number of legs.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
2. Organisms differ in structure and function and have characteristics that help them survive and reproduce in different environments.	a. interpret and explain patterns and relationships of the animals' structure and systems based on data given about different animals (1.6; 1.7; 1.8; 2.2)	• Examine crickets, mice, birds, etc., and explain how different physical structures help them survive.
3. Plants and animals are alive and have characteristics that make them different from nonliving matter.	a. identify characteristics that determine whether an object or material is living or nonliving and apply that knowledge to unknown samples (1.2; 1.3; 1.6)	• Describe how a tree and a turtle differ from a rock. List these characteristics and identify the similarities and differences that exist.

VII. Living Systems B. Life Processes

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Organisms go through life cycles.	a. observe and record the phases in the life cycle of various organisms and compare the differences between species (1.3; 1.6; 2.4)	• Discuss the human life cycle and generate some reasonable questions about differences in various developmental stages—newborn, child, adolescent, adult, elderly. • Create an illustration that depicts physical changes in an animal from birth to maturity.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
2. Most organisms require a variety of materials including food, water, air, and a suitable environment for survival. Animals obtain energy and nutrients from plants or other animals.	a. conduct investigations to gather data, information, and ideas relating to the energy and nutrients organisms need from their environment in order to survive (1.3) b. summarize the effect of various conditions on plant and animal survival tactics (2.1; 2.3)	• Compare a human's energy and material needs for growth to the same needs for other organisms. • Explore a simple, natural system (e.g., classroom aquarium or outdoor habitat) and generate questions about the transfer of energy and use of nutrients.
3. Organisms are composed of parts that work together and exhibit behaviors that ensure the survival of the whole organism.	a. discover and evaluate patterns and relationships between the parts of organisms that work together and the behaviors that ensure the survival of the whole organism (1.7; 1.8)	• Observe and record the behaviors of plants under a variety of conditions (e.g., changes in light, water, composition of soil, and use of fertilizers) and relate the observations to the plants' requirements for survival.

VII. Living Systems C. Diversity

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Organisms can be grouped by specific structures.	a. group organisms according to similar specific structures (1.6)	• Group students by hair color, eye color, etc.
	b. compare living things using one or more structure attributes (1.6)	• Distinguish between types of plants by comparing size, leaves, shape, blossoms, etc. • Sort pictures of animals by physical traits such as: exoskeletons, shells, hair, feathers, scales.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
2. Some characteristics of organisms are inherited and some are acquired as a result of interaction with the environment.	a. identify and consider a variety of viewpoints when interpreting whether characteristics are inherited or acquired (2.3; 3.4)	• Investigate and describe the habitats of local organisms. Identify physical structures and behaviors that enable them to survive in their environment.

VII. Living Systems D. Reproduction/Heredity

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Most offspring are similar but not exactly like their parents.	a. identify and discuss the similarities and differences between parents and their offspring (1.6)	• Observe parents and offspring of various species and draw reasonable conclusions about the inheritance of traits such as body shape, coloration, and behavior.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
2. Organisms resemble their parents because they inherit physical characteristics from them. Organisms with two parents inherit characteristics of both.	a. organize physical characteristics of offspring and parents into useful forms for communicating visual clarity and interpret patterns and sources of inheritance (1.6; 3.2)	• Chart and interpret data about inherited characteristics from an actual or hypothetical human biological family. Identify similarities and differences.
3. All types of living organisms have offspring, and the similarities between parents and their offspring become more apparent as the offspring mature.	a. design and conduct investigations to observe and compare similarities and differences between offspring and their parents (1.3; 1.8)	• Observe and compare similarities and differences between mature birds/nestling, butterflies/caterpillars, etc.
4. The phases in the life cycle of all living organisms are predictable, but differ from species to species.	a. design and conduct investigations to observe and record the life cycles of organisms (1.3; 4.6)	• Observe and record the life cycles of an insect, a frog, and a dandelion. Compare the differences.

VII. Living Systems E. Adaptation/Evolution

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Organisms have parts that enable them to live and survive in the world.	a. organize data, information, and ideas about how body parts enable the organism to live and survive (1.8)	• Identify and discuss the functions of arms, legs, mouth, eyes, etc., in seeking and consuming food. • Identify the functions of the various plant structures in growth and development. • Discuss and compare the functions of fins, wings and legs for animal movement.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
2. Organisms of the same species can have variations that provide an advantage in survival and reproducing.	a. design and conduct investigations to observe and describe variations in organisms and to predict how the variations provide an advantage in survival and reproduction (1.3; 1.7; 3.2)	• Observe and describe variations in a species (e.g., length of bean seeds, height of radishes, leg length in grasshoppers). Predict how variations may affect the ability of the organism to survive.
3. Fossils give evidence that organisms that lived in the past were both similar to and different from present-day organisms.	a. design and conduct investigations to observe similarities and differences in fossils as compared to present day organisms and develop reasonable questions that would account for the differences (1.3; 1.5, 2.2; 4.6)	• Observe and compare the similarities and differences between fossils and common present day organisms.

VII. Living Systems A. Structure/Function/Characteristics

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Organisms can be classified into kingdoms based on similarities and differences.	a. develop and use a classification key that can be used to place common organisms into proper kingdoms (1.1; 2.4; 3.3; 3.7)	• Sort a collection of objects, such as shoes, and create a dichotomous classification key for these objects. • Develop a dichotomous key for the five kingdoms and then use it to sort organisms into the appropriate kingdom.
2. The basic unit of life is the cell. Different cells are specialized to perform various tasks. Cells of similar shape and function are organized into groups.	a. use appropriate technology and other resources to get a visual understanding of the cell as the basic unit of life. Design and conduct investigations to explain why organisms need specialized cells (1.2; 1.3; 1.4; 2.7)	• Examine different types of cells, tissues, and organs and explain why animals need specialized cells (red blood, white blood, muscle, nerve). Do the same for plants (stem, root, leaf).
3. In living systems, from cells to biosphere, components interact within a hierarchy of organization.	a. use a variety of technologies and resources to conduct inquiries into a living system and describe the interaction of components and organisms within any living system (1.3; 1.7)	• Establish an ant farm or bee colony and identify levels or organization.
4. Cells contain a set of structures called organelles that control the various functions of the cell.	a. use appropriate technology to get a visual understanding of organelles; conduct investigations and research on the structure and function of various cell organelles (1.2; 1.4; 2.7)	• Investigate and describe various life processes in unicellular organisms such as amoebae, paramecium, and yeast. • Identify and explain the functions of various organelles (cell wall, cell membrane, nucleus, etc.).

VII. Living Systems B. Life Processes

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Energy is needed for living cells to carry out all the processes of life.	a. design and conduct investigations and organize data, information, and ideas about how energy is needed for living cells to carry out all the processes of life (1.2; 1.3; 1.6; 3.1; 4.6)	• Record individual food intake and daily activities for 3 days. Create a table showing the calorie intake and usage that corresponds to daily activities. Participate in class discussions focused on energy requirements of the processes of life.
2. In the process of photosynthesis, green plants convert water and carbon dioxide into energy-rich simple sugars and oxygen.	a. conduct simple experiments with green plants to determine the requirements and products of photosynthesis (1.3; 1.8)	• Measure oxygen bubble production of elodea in water as evidence of photosynthesis.
3. Complex multicellular organisms are interacting systems of cells, tissues, organs, and organ networks that carry out life processes through chemical and physical means.	a. organize information into a model that demonstrates the interaction of systems of cells, tissues, organs, and organ networks in a complex multicellular organism through chemical and physical processes (1.2; 1.5; 2.1; 2.3; 2.4)	• Use models or organisms to learn how organ and organ systems in plants and animals work together for the well-being of the entire organism.

VII. Living Systems C. Diversity

By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. A species is an important biological grouping of organisms whose members have similar structures, normally interbred, and produce fertile offspring.	a. review and revise the definition of a species in order to improve understanding and clarity and apply the definition to sample situations (1.6; 2.2; 2.3; 4.1)	• Determine, using the definition of the word "species," the number of species present in a sample containing numerous kinds of organisms.
2. Each structure in an organism is uniquely adapted to a particular function for enhancing the ability of the organism to survive.	a. design and conduct investigations and research on how an organism is uniquely adapted to a particular function for enhancing its ability to survive (1.2; 1.3; 1.4; 2.7; 4.6)	• Describe and compare internal and external structures of different plant and animal species that perform a common function (leaf structure of desert/tropical plants, tooth shapes of carnivores/herbivores, breathing organs of aquatic/terrestrial animals, etc.).

VII. Living Systems D. Reproduction/Heredity

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The sorting and combination of genes in sexual reproduction results in a greater variety of possible gene combinations than in asexual reproduction that results in offspring genetically identical to the parent.	a. present a visual representation of variation in offspring due to sexual reproduction or how asexual reproduction results in genetic clones of the parent (1.3; 1.8, 3.5; 4.6)	• Design a laboratory inquiry with sexually reproducing organisms to study the transfer of genetic materials expressed as traits, from one generation to another. • Design laboratory inquires that allow observation of asexual reproduction in yeast, hydra, or plants and identify important characteristics of this type of reproduction. Discuss the difference between asexual and sexual reproduction.
2. Chromosomes are components of cells that occur in pairs and carry hereditary information from one cell to its daughter cells, and from a parent to its offspring.	a. use models to demonstrate how genetic material is transmitted and how gene traits are expressed in offspring (1.3;2.2)	• Demonstrate that chromosomes and genes come in pairs and are composed of many genes. Discuss how genetic material is transmitted. • Use Punnett squares and pedigree charts to demonstrate how single gene traits are expressed in offspring.
3. In sexual reproduction, each gamete contributes a set of chromosomes to the offspring, giving it the traits of both parents.	a. organize data, information, and ideas into a visual representation of the patterns and relationships involved in the chromosome contributions of gametes in sexual reproduction (1.6; 1.7; 1.10; 2.1; 3.2; 4.6)	• Describe sexual reproduction patterns in flowering plants and a variety of animals.
4. Each cell of a developing organism receives an exact copy of the genetic information contained in the fertilized egg.	a. organize data, information, and ideas to explain the stages through which a fertilized egg or seed changes into its adult form (1.2; 1.4; 1.8; 2.3)	• Observe, describe, and measure changes that occur in a bean plant, frog, or chicken as it develops from a seed or fertilized egg to an adult.

VII. Living Systems E. Adaptation/Evolution

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Natural selection is the process that ensures individuals with certain traits are more likely to survive and have offspring of the same species.	a. research the evolutionary adaptations of a number of present-day organisms and explain how these adaptations contributed to the survival of the organism (1.2)	• Describe the differences between short-term physiological adaptations (skin tanning, loss of a lizard's tail, calluses, etc.) and evolutionary adaptations occurring over generations (beak shape, protective coloration, flower color, etc.).
2. Changes in populations are often, but not always, driven by gradual or catastrophic changes in environmental conditions.	a. evaluate information, ideas, arguments, and products to determine patterns, relationships, perspectives, and credibility relating to changes in populations due to environmental conditions (1.5; 1.7; 1.8; 2.1; 2.4; 2.6)	• Observe and describe changes that occur during the development of animals. Explain how environmental factors could affect development.
3. A successful population can adapt to environmental changes through genetic variations.	a. present ideas, opinions, and arguments in an organized and convincing way stating the differences and similarities between successful populations and their environments (2.4)	• Conduct a natural selection simulation to demonstrate that a specific trait has selective advantage for an organism.
4. The study of fossil records and living organisms provides evidence of the appearance, diversification, and extinction of many life forms.	a. organize information and data to demonstrate the appearance, diversification and extinction of many lifeforms (1.5; 2.2)	• Create a timeline of the appearance and disappearance of different species in the fossil record. • Use technology and resources to describe the environment in Missouri during the time period in which a given fossil was living.

VII. Living Systems A. Structure/Function/Characteristics

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Cells are the fundamental structural and functional units of all living organisms and take highly varied forms in different plants, animals and microorganisms.	a. use appropriate technology and other resources to compare and contrast ways in which special cells carry out reproduction, photosynthesis, respiration, mitosis, meiosis, etc. (1.4; 1.6)	• Use microscopes to observe, sort and group cells according to their specific properties.
2. Cells have distinct and separate structures that perform and monitor processes essential for the survival of the cell and/or organism, such as chemical synthesis, energy conversion, material transport, and cell replication.	a. investigate, observe directly or indirectly, and communicate to others the basic life processes that take place at the cellular level (1.2; 1.4; 2.1; 2.3)	• Construct a simple experiment to compare the effect of concentration gradients on the movement of materials across cell membranes. • Use computer simulations or special lab materials and equipment to investigate chemical synthesis, energy conversion, cell replication and differentiation at the cellular level.
3. DNA indirectly controls what cells do and when they do it by conveying encoded information directing the cell's synthesis of protein molecules.	a. present perceptions and ideas explaining the process whereby DNA directs the synthesis of proteins from amino acids (2.4)	• Working in groups, create a computer animation illustrating the processes whereby DNA directs the synthesis of protein.
4. Organisms are classified into a hierarchy of groups and subgroups, based on their structural similarities and reflecting as much as possible their evolutionary relationships.	a. classify organisms into groups and subgroups based on structural similarities and then compare to published classifications of the same organisms based on evolutionary and molecular data (1.2; 1.6; 1.7; 1.8)	• Using a collection of toy organisms, classify them based on morphological features. Then compare and contrast this with actual evolutionary relationships of these organisms.

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Cells carry out chemical transformations that allow conversion of energy from one form to another, the breakdown of molecules into smaller units, and the building of larger molecules from smaller ones.	a. use models to demonstrate various chemical transformations carried out by cells and apply this information to different contexts of everyday life (1.10; 2.7)	• Use models to demonstrate and discuss the mechanism of enzymatic action. Create skits that relate this process to an athlete's performance in a specific sport.
2. Photosynthesis and cellular respiration are complementary processes.	a. design and conduct investigations to determine what factors affect the processes of photosynthesis, anaerobic respiration, and aerobic respiration (1.7; 2.1; 2.2)	• Design tests involving elodea, a snail, and a pH indicator to develop reasonable explanations concerning the complementary relationship between photosynthesis and cellular respiration. • Conduct laboratory investigations to determine the requirements for and the products of photosynthesis. • Conduct investigations to determine how temperature affects the rate of cellular respiration of small invertebrates.
3. Optimum conditions are maintained in an organism as a result of special functions performed at the cellular level.	a. recognize and communicate logical relationships between general body conditions (such as fever or intoxication) and specific cellular processes (1.6; 2.4; 3.5)	• Carry out investigations of the effects of various drugs on the heart rate of daphnia.

VII. Living Systems C. Diversity

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Similarities in DNA and protein structure can be used to classify and determine degrees of kinship among organisms.	a. read and interpret representative examples of published primary articles discussing current research in the use of molecular similarities to determine degrees of kinship of organisms (1.2; 1.5; 1.7)	• Conduct a series of debates concerning the usefulness and accuracy of specific techniques used by scientists for determining degree of molecular similarity. • Use gel electrophoreses or data from gel electrophoreses to determine the genetic divergence and evolutionary relationship among species of plants and animals.
2. Variations of organisms within a species and diversity among species increase the likelihood that at least some organisms will survive in the face of large changes in the environment.	a. measure the amount of variation in a defined population of organisms, graph this variation, and relate this variation to the population's ability to survive environmental change (1.8; 3.5)	• Conduct a laboratory investigation or a simulation to demonstrate that variations within a species may enable organisms to survive large -cale environmental change.

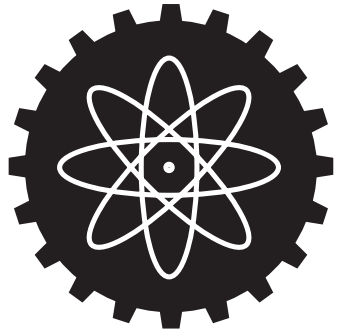
VII. Living Systems D. Reproduction/Heredity

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Heredity/genetic information is contained in molecules of DNA that consist of various combinations of four different subunits that encode this information.	a. evaluate the accuracy of information provided in the news media regarding current topics related to genetics (1.7; 1.10; 4.1)	• In a mock criminal trial, use models of DNA, RNA, amino acids, etc., to learn about the structure of nucleic acids and the process by which DNA directs the synthesis of proteins.
2. The pattern of inheritance for many traits can be predicted by using the principles of Mendelian genetics.	a. using existing models that demonstrate patterns of inheritance (e.g., Punnett squares), make predictions as to probabilities and patterns of inheritance for resulting inherited traits in organisms (1.5; 1.6; 1.10; 2.2; 3.3; 4.1)	• Use Punnett squares and pedigree charts to determine probabilities and patterns of inheritance of seed shapes of pea plants.
3. Coding error in DNA synthesis (mutation) can occur randomly during replication and can also be caused by heat, radiation, and certain chemicals.	a. use models of DNA, RNA, amino acids, etc., to demonstrate how mutations affect the structure of proteins (1.6; 2.1)	• Conduct investigations of the rates of mutation in fruit flies resulting from exposure to various mutagens.
4. In asexual reproduction of unicellular organisms (and mitosis in multicellular organisms), DNA of parent cells replicates to form identical chromosomes and genes as the cell divides into two identical offspring cells.	a. create a visual representation of the molecular mechanisms that cause asexual reproduction to result in identical offspring and sexual reproduction to result in variation in offspring (1.3; 2.1)	• Use prepared slides and models of plant and animal cell mitosis to describe changes that occur during the cell cycle.
5. Embryological development in plants and animals involves a series of orderly changes in cell division and differentiation.	a. apply acquired information pertaining to embryological development to responsible decision making regarding health of developing human fetuses (1.3; 1.6; 1.7; 1.10; 3.5)	• Conduct investigations of the changes that take place in a plant seed as it develops into a mature plant and determine how development is affected by external and internal factors.

VII. Living Systems E. Adaptation/Evolution

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Evidence for the nature and rates of evolution can be found in anatomical and molecular characteristics of living organisms and in the fossil record.	a. examining a real or simulated example of stratified layers of sediment containing fossils and analyze anatomical changes that occur from layer to layer. (1.2; 1.3; 1.6; 1.7; 3.5)	• Use anatomical and molecular characteristics of specimens, fossils, and models to illustrate the nature and rates of evolutionary change. • Examine the muscles, joints, and bones of an animal. Record similarities and differences to current models of its prehistoric ancestors.
2. The process of natural selection provides that some heritable variations that arise from mutation and recombination give individuals within a species some advantage over others for survival.	a. conduct laboratory experiments looking at artificial selection and apply the understanding acquired from these experiments to natural systems in which selection occurs because of environmental conditions. (1.2; 1.3; 1.6; 1.10)	• Participate in natural selection simulation activities in which students play the role of birds feeding on insects, picking colored toothpicks from piles of grass. The "survival" rate of "insects" of each color is recorded.
3. Evolution does not proceed at the same rate in all organisms; nor does it progress in any set direction.	a. research our present understanding of the course of evolution of specific types of organisms, identify random events that may have influenced this course, then predict possible alternative courses of evolution that could have resulted had these random events not taken place. (1.2; 1.6; 3.3; 3.5	• Examine fossil and modern horse anatomy to identify those traits that were perpetuated and those that were eliminated. Discuss possible reasons why one trait did not progress along a predictable path.

VIII. ECOLOGY
(SHOW-ME STANDARDS, SCIENCE 4)



A. Interactions
B. Changes

K-12 Content Overview:

Knowledge of the living environment provides students with an understanding of their place in the natural world and of how humans can impact the environment to the benefit or detriment of themselves and other living organisms. Students generally know from everyday experience that in order to survive, organisms depend upon other organisms and the physical environment in which they live. But their awareness must be supported by knowledge of the types of interactions that occur among organisms, the kinds of physical conditions that organisms must cope with, and the complexity of the systems that are created through interdependence and interaction.

Living systems maintain a relatively stable internal environment through their regulatory mechanisms. Energy flows through an ecosystem from the Earth's primary source of energy, the sun, to organisms that can transform light energy into chemical energy. Other organisms then depend upon this chemical energy, in the form of food, to survive. While energy continually flows to Earth from the sun, matter on Earth is limited. Over periods of time, varying from days to eons, matter cycles between the living and nonliving environment.

The concept of evolution provides a framework for understanding the diversity and interdependence of life forms. All ecosystems change over time. Individual organisms that are best adapted to these new environments tend to survive and reproduce, leading to shifts in populations. The diversity of behaviors, structure, and biochemical characteristics within a population increases the likelihood that individuals will have characteristics that are beneficial in a changed environment.

VIII. Ecology A. Interactions

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. All living organisms interact with each other and their environment.	a. give examples of how living things affect their environment and other living things (1.3; 1.6; 4.1)	• Investigate an outdoor plot to identify worms, bugs, birds, plants, etc. Give examples of how these things affect their environment and each other.
2. All organisms depend on one another and their environment to live and grow.	a. identify the common basic needs of organisms and the ways in which they depend on each other and their environment (1.1; 1.2; 1.3; 1.6; 1.10; 2.4; 3.5; 4.6)	• Study an aquarium and record how each organism contributes to the natural system of the aquarium. • Identify several animals that live in the local area. Investigate what food and environment they need to survive. • Investigate and discuss how different types of seeds are designed to be dispersed and the process of dispersal. • Design a fictitious animal or plant with the physical characteristics that will let it live and grow in a particular environment.
3. People depend on other organisms and Earth's resources for clothing, shelter, and food.	a. identify ways humans depend on other organisms for food, clothing, and shelter, etc. (1.2; 2.3; 4.1)	• Determine the sources of the different materials used to make clothes. • Chart the process by which food is grown, processed, and brought to our homes. • List common building materials and categorize them into "natural" or "human-made."

VIII. Ecology A. Interactions

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
4.. Behavior patterns and survival of organisms result from their interactions with a specific environment.	a. predict how specific changes in the environment will affect people and other organisms found in this environment (1.1; 1.3; 2.4; 3.2; 3.4; 3.5; 4.1; 4.6)	• Plan and conduct simple investigations to explore how modifications in soil, water, and sunlight affectsthe growth and survival of a plant.
	b. identify behavior and physical adaptations that help organisms adapt to changing conditions (1.2; 1.5; 2.4)	• Explain how humans and animals are affected by temperature, rainfall, violent storms, earthquakes, floods, etc., and how they adapt.
	c. identify the physical attributes and behavior of living organisms that enable them to survive (1.2; 1.5; 2.4)	• Investigate and describe the habitat of an owl. Identify physical attributes and behaviors of the owls that enable them to survive in their environment.
5. Organisms interact with each other as producer/consumer, scavenger, predator/prey, parasite/host, decomposer, etc.	a. identify and discuss the nature of relationships between two or more living organisms (1.2; 2.3; 2.7; 3.5)	• List ways that hawks, mice, and plants interact in an ecosystem. Identify the interdependent relationships that exist (such as predator/prey).
6. Interactions between organisms and their environment contribute to continous cycling of matter and energy.	a. describe how organisms within a contained system maintain their relationships over time and what adjustments occur naturally within this system (1.1; 2.1; 3.1; 4.1)	• Conduct an extended investigation (terrarium, aquarium, local habitat) to explain how the inhabitants meet their energy needs. Generate reasonable questions about these interactions and design simple tests to investigate these questions.
	b. develop a food web to show the energy flow from any organism to another (1.8; 2.2; 3.5)	• Use pictures of plants, insects, birds, animals, and microorganisms to illustrate the flow of energy from producers to decomposers.

VIII. Ecology B. Changes

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. All organisms, including humans, cause changes in their environments that can be either beneficial or harmful to the organisms in the ecosystem.	a. observe and record environment alchanges and the reactions of organisms to these changes over time (1.2; 1.5; 2.4; 3.1; 3.5; 4.1)	• Change the environment of a terrarium by changing the temperature and record how the invertebrates react. • Select a local area and investigate the influence of human activity on that area. • Investigate how modifications in a plant's environment (soil, moisture, sunlight) affect its growth and survival.
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
2. Organisms that survive in an environment have developed adaptations that allow the organisms to compete for available resources and cope with the physical conditions of their environment.	a. identify positive adaptations of organisms to a given environment that increase chances for survival (1.3; 1.4; 2.3; 3.5; 4.1)	• Observe a variety of local plants and animals in an area. Identify the features of these organisms that make them suitable for that habitat.
3. Human activities can change the environment in ways that affect the health and survival of all living organisms.	a. explain how human activities can affect the environment in positive and negative ways (1.1; 1.2; 1.3; 1.4; 1.8; 2.1; 2.7; 3.5)	• Identify a classroom or school environmental issue (recycling, conserving electricity, cafeteria waste). Design and implement a plan to address the issue. • Investigate the impact of human activities or land development on various Missouri species (deer, opossum, turkey, buffalo clover, lady's slipper, etc.).
4. Changes in an environment, caused naturally or by humans, can be beneficial or harmful to the organisms living in that environment.	a. identify changes in an environment as beneficial or harmful (1.1; 1.2; 1.3; 1.4; 1.6; 1.8; 3.5; 4.1)	• Investigate how a pond changed over a 2-year period. Classify these changes as either a result of physical forces or from actions of humans. Identify the effects of the changes on the living organisms of that pond.

VIII. Ecology A. Interactions

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. As energy flows through the ecosystem, all organisms must transform the portion of energy available to them and into usable forms.	a. relate trophic levels and food webs to the flow of energy in an ecosystem (1.4; 1.6; 2.7; 3.5; 4.6)	• Investigate the relationship between the available energy in a local ecosystem and the types and numbers of species it will support. • Use the 10% law and design an ecological pyramid showing the energy contained in the biomass at each level.
	b. trace energy repossessions within specific food webs (1.4; 1.6; 2.7; 3.5; 4.6)	• Analyze a variety of food webs, identify the organisms at each trophic level, and account for the flow of energy from one trophic level to another.
2. Matter is recycled in an ecosystem, changing orm and location.	a. relate energy flow and matter recycling to each step of a food web (1.4; 1.6; 1.8; 2.1; 3.5; 4.6)	• Describe how matter is recycled and some energy is lost in each step of a food web.
	b. explain the flow of matter and energy through an ecosytem and living systems (1.4; 1.6; 1.8; 2.1; 3.5; 4.6)	• Construct a flowchart to illustrate how matter, chemical nutrients, and minerals are cycled through the living and nonliving parts of an ecosystem.
3. Abstract concepts of global environment can be applied to complex interactions of the biotic and abiotic factors that affect populations and ecosystems.	a. speculate on the environmental changes that would have global impact and discuss the mechanisms by which the changes become global (1.1; 1.2; 1.3; 2.1; 3.5; 4.6)	• Investigate the "greenhouse effect" and relate it to possible changes in the biosphere. • Participate in policy formation simulations based on actual case studies involving the use of natural resources. Address the need to balance short-term economic policies with long-term resource planning.
4. All organisms, including humans, are part of and depend on one global food web that begins with organisms at the bottom of the energy pyramid.	a. apply the knowledge learned to describe examples of interacting organisms and classify them as beneficial, competitive, or detrimental to each other for survival (1.7)	• Construct simple diagrams of food chains to trace the flow of matter and to categorize the organisms of the food chain according to the function they serve. Use several food chains to design a food web that illustrates the interrelationships among the organisms in an ecosystem.

VIII. Ecology B. Changes

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The variation of characteristics in a population increases the likelihood that some members will survive the physical or biological changes of that system.	a. explain how the variation of organisms within a certain population increases the likelihood of survival of the species (1.2; 1.3; 1.10; 2.1; 3.8; 4.1)	• Investigate the response to disease and/or pests demonstrated by hybrid plant species developed for agriculture.
2. The diversity and balance of species in an ecosystem changes when environmental conditions change.	a. identify environmental changes that affect the diversity and balance of an ecosystem and suggest alternative approaches that are less intrusive (1.2; 1.4; 1.9; 2.1; 3.2; 3.3; 3.5; 4.1)	• Determine the amount of variation in population of mayfly larvae in streams. Compare this variation with the different water quality of the streams. • Investigate the change over time that plant communities may undergo growing along ditches, fences, edges of forests, under power lines, etc., may undergo. • Investigate case studies that indicate how humans impact the environmental conditions that affect the equilibrium of an ecosystem. • Analyze the human population data of a Missouri county or a city over a 100-year period. Discuss reasons for increases/decreases and the impact on the natural resources of the area.

VIII. Ecology A. Interactions

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. No two species occupy the same niche in an ecosystem so that different species can coexist and help maintain the stability of that system.	a. observe and identify competitive and cooperative interrelationships among species of a local ecosystem (1.1; 1.3; 1.4; 1.6; 2.4; 3.5; 4.1; 4.6)	• Evaluate the interrelationships of animals and plants of a local ecosystem. Identify ways they help maintain the stability of the ecosystem.
2. Human decisions concerning the use of resources can alter the stability and biodiversity of ecosystems.	a. research the methods of obtaining fossil fuels and their impact on ecosystems (1.4; 1.6; 1.8; 1.10; 3.2; 3.3)	• Explain the possible impact strip mining has on the ecosystem of the area in which it is used. • Research Missouri hunting or fishing regulations for a species and create a timeline comparing population numbers to changes in the regulations.
	b. explain the possible consequences of a reduction in biodiversity (3.1; 3.2; 3.3; 3.8)	• Research and discuss the consequences that may result from the reliance on one strain of wheat or one preferred animal stock.
3. Increased demand for natural resources require global cooperation and long-term planning to ensure the resource needs of successive generations will be met.	a. compare the use of natural resources in developing countries to the use in industrialized nations (1.2; 1.4; 1.7; 2.3; 2.7; 4.1; 4.6) b. discuss how technology has provided a more efficient use of resources and extended their availability (1.4; 1.7; 2.3; 2.7; 3.5; 4.1)	• Research and compare the use of natural resources in a Third World country to the use of natural resources of the United States. • Compare and contrast the process of getting food from the farm to the table before 1945 and after.

VIII. Ecology B. Changes

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should be able to*	*These samples activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Ecosystems are interconnected by biological, chemical, and physical processes so that changes in one ecosystem can have local or global consequences.	a. observe and identify biological, chemical, or physical processes of one ecosystem that affect other ecosystems (1.2; 1.4; 1.6; 2.3; 3.1; 3.5; 4.1)	• Investigate the effects of El Nino on plants and animals of the Midwest over the last 10 years.
2. Overpopulation in an ecosystem can lead to depletion of resources and elimination of a species.	a. identify the density-dependent limiting factors of a population and discuss consequences of overpopulation (1.6; 2.1; 2.3; 3.5; 4.1)	• Investigate the deer population in Missouri over the last 10 years. Discuss the pros and cons of harvesting the deer.
	b. discuss how changes in one population in an ecosystem affects the population of another species in that ecosystem (1.2; 1.4; 1.8; 2.1; 2.2; 2.3; 2.4; 2.7; 3.5; 4.1)	• Analyze and discuss how logging practices of the Pacific Northwest affected the northern Spotted Owls.
	c. identify the carrying capacity of an ecosystem and predict the limiting factors that will slow population growth (1.1; 1.4; 1.6; 1.8; 2.1; 3.5; 4.1)	• Explore the carrying capacity of the Earth for humans. Discuss the implications of a growing population on Earth's resources and possible lifestyle changes of humankind.